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# QUARTERLY

OF THE

# National Fire Protection Association

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87 MILK STREET BOSTON, MASS.

# National Fire Protection Association.

(INTERNATIONAL.)

**Executive Office, 87 Milk Street, Boston, Mass., U. S. A.**

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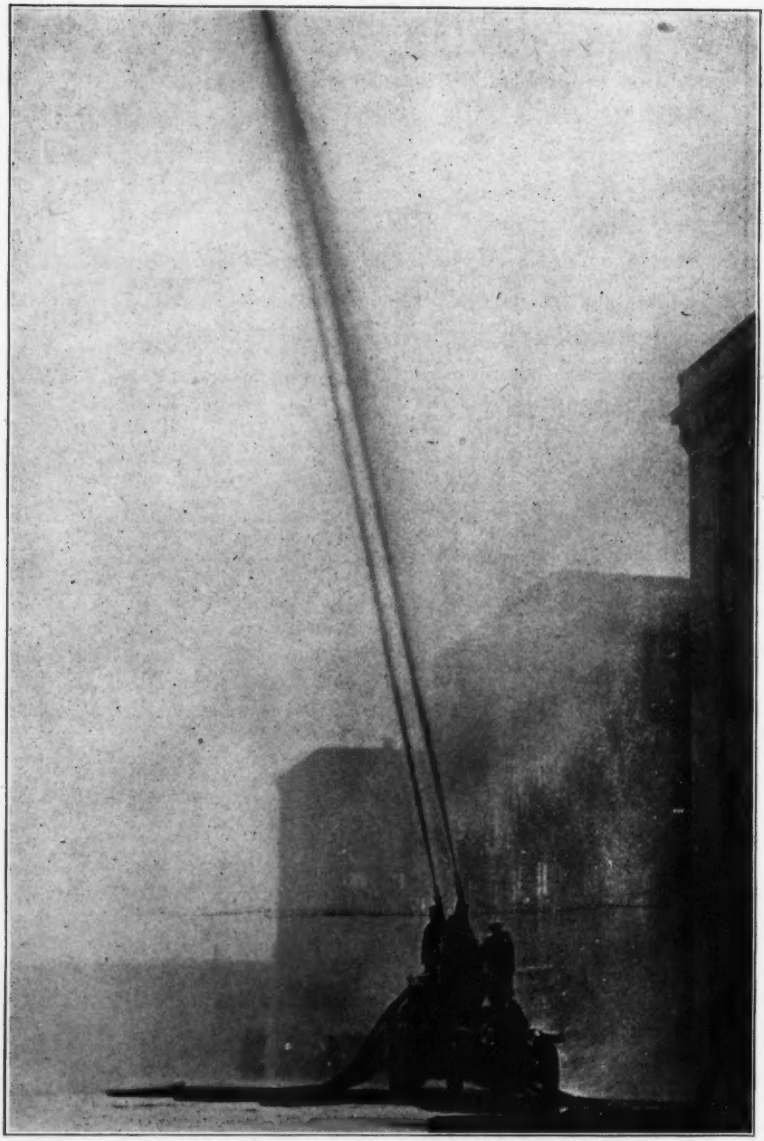
*Reports of fires appearing in the* QUARTERLY *are copies of or extracts from written reports forwarded to the Association. This Association, as a body, is not responsible for the statements or opinions of any of its members.*



Recent Test of one of Boston's new High Pressure Cars, designed for use with the new High Pressure System. (See Article on Page 31).

# The Quarterly

Vol. 15 July, 1921 No. 1

**The Twenty-fifth Annual Meeting.** The members of the Association who attended the "silver jubilee" convention at San Francisco in June enriched their lives by more than one delightful experience. The days together on the N. F. P. A. special train, cementing old friendships and making new ones; the visit to Grand Canyon with its descent to the river on mule back; the long day at Barstow, an aftermath of the flood which wrecked Pueblo and the Santa Fe main line were but interesting preliminary adventures to the great adventure of San Francisco itself. Thanks to San Francisco Chapter N. F. P. A. and its devoted members, the social side of the annual meeting in both its formal and its informal aspects was beyond anything on record; a book might be written about it. The high spots of the entertainment program were the amazingly successful luncheon at the Palace Hotel under the direction of Mr. J. H. Shively, the afternoon automobile ride, without reference to speed limit, executed by Chief Thomas R. Murphy, and the informal dinner at a San Francisco beach resort, arranged by Clarence Heller.

The published *Proceedings* of the twenty-fifth annual meeting, when the volume finally appears, will show that the actual work performed by this Convention was quite the equal in volume and quality of any other convention. The discussions were as animated and the accomplishments as definite as they would have been had the meeting been held in Chicago or New York. The attendance from the East, while limited, was truly representative of the country as a whole as was shown by the registration from Boston, New York, Baltimore, Atlanta, Nashville, New Orleans, Chicago, Dallas, Denver and other cities. There was a good attendance from the Pacific Coast and of San Francisco Chapter members. Canada alone was not adequately represented.

* * * * *

**The Evening Telegram's Editor Nods.** If it is true that Homer nodded once, there is nothing extraordinary in a modern editor, looking about for copy to fill his columns, occasionally falling actually into a pit. Paragraphs which appear just long enough to fill a gap in the make-up are wonderfully seductive to the desk man who wishes to go to the ball game. The QUARTERLY editors have rather relentlessly flayed the publishers of middle-class weeklies who have printed long articles glaringly violating the common sense of fire protec-

tion, but have seldom had occasion to castigate anybody at the desk of a metropolitan daily.

Someone on the *New York Evening Telegram*, however, recently slipped a cog. This brief article, so fascinating in its suggestions to the dwellers in the steam-heated flats of Manhattan, lately flashed its seductions from the *Telegram's* editorial page:

### THE ELECTRIC CORD

There are two ways to make the businesslike look of an electric light extension cord that is stretched across a room more attractive. One way is to hide it. And the other way is to decorate it.

If the electric socket, which furnishes the light, is on a side wall, either high or low, the connecting cord can be run, in many cases, for a partial distance along the floor by the side of the room, and as the edge of the floor is not walked on as a rule, the cord can easily be made inconspicuous, by covering it with a rug.

If the cord is connected with a socket in the ceiling or from chandeliers there is apt to be six or more feet of cord draped across the upper part of the room to a position that will give light to a desk, table, couch or piano, and to camouflage this cord makes it a point of decorative interest.

A decoration that is particularly pleasing is a flock of birds that give the effect of being in flight. Red birds, black birds, blue birds, or even white "doves of peace" are very effective, cut out of heavy paper or light weight cardboard in the form of flat, but life-sized, birds "on the wing" and strung on string the same color as either the birds or the electric cord, or fine wire, and attached to the electric cord. The flying birds some way bring a cheerful, spacious, outdoor feeling into a room, and such a decoration in a school room or children's room in a library would surely appeal to the kiddies.

For party decoration, either, the electric light cord should not be overlooked, for it can be strung or wound with a variety of paper trimmings, such as flowers, hearts, flags, pennants and emblems symbolic of such holidays as St. Patrick's Day, Hallowe'en and Christmas.

Nothing of value in a New York newspaper ever escaping the literary peregrinations of our distinguished former president, F. J. T. Stewart, it was not long before his attention was arrested by this solemn advice to the silly, and deeming it a matter worthy of consideration by the N. F. P. A. ex-Presidents' Association, he sent it at once to the founder of that exclusive and aristocratic body, William Henry Merrill of Chicago. Mr. Merrill is remembered as the president who once made a speech at a banquet at Hotel Astor in which he said the secretary of the Association had a head like David Belasco's.

It was Mr. Stewart's idea that a mildly ironical paragraph added to this article on the Electric Cord might jar the editor of the *Telegram* if it came from some point far enough away from New York City, and he suggested something like the following:

> As a further camouflage and one having an educative content we would suggest a combination of literative and decorative art by fastening copies of the National Electric Code to the tail feathers of the birds in flight, especially featuring the paragraphs on flexible cord and what not to do with it.

Mr. Merrill liked this paragraph of Mr. Stewart's. He admitted that it was drawn to scale, or, if it wasn't, it had, anyhow, a very pretty perspective. He was afraid, however, that its irony was a bit too subtile to be representative of Chicago, which always wishes to "do something about it." If sent forward, the editor of the *Telegram* might suspect the source as "somewhere East." So the Laboratories' engineers were called in. Every man-jack of them asserted that as New York is not concerned with intellectual progress and is at present confused by an immeasurable mental discord, Mr. Stewart's effort to synthesize the knowledge that exists there must of necessity be unfruitful, being an adventure in the larger sphere of the mind. With the metropolis in its present state any educational undertaking must be dramatized in some objective form, say that of a policeman; because, while New York was puzzling its brains to discover if Mr. Stewart's suggestions were really serious, everything combustible on Manhattan Island except the subway might be burned.

It was, therefore, the unanimous thought of the Laboratories' staff that a concluding paragraph of the *Telegram's* article should read something like this:

> The decorative effect could be further enhanced by running a line of automatic sprinklers with adequate water supply along the line of the cord and arranging to have a member of the fire department in new uniform and full equipment stationed in the premises night and day, including Sundays and holidays.

The practical mind of Chicago speaks in this paragraph. Do something now; preserve Manhattan from its fate; interpret to it in some way its violent material absurdities; mellow it; enlighten it; saturate it with fertile ideas, and some day, perhaps, even the editors of its newspapers may display common sense.

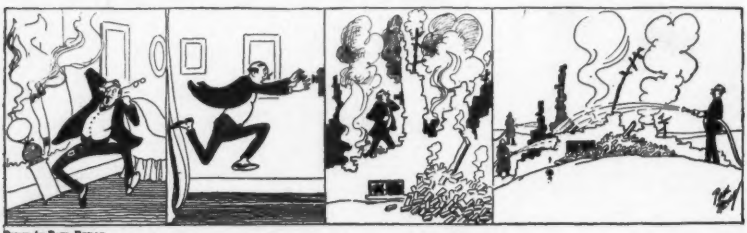
# A Party Line Menace.

Secretary Sanislo of Seattle Chapter has sent newspaper clippings of the following interesting fire:

A large homestead on the shore of Lake Washington, Seattle, was completely destroyed by fire due to an overheated flue. The owner of the house next door noticed the fire near the start and promptly tried to telephone the fire department. A man was talking and he requested him to hang up a minute so that he could put through his urgent call. He was told to get off the line until the man was through and a period of fifteen minutes elapsed before the department could be summoned. This telephone was the only one in the neighborhood. By the time aid arrived the flames had gained such headway that it was practically useless to try and extinguish them and the firemen devoted their attention to saving furniture and preventing the spread of fire to other dwellings. Shortly after the fire started a gas pipe near the flue sprang a leak and the escaping gas fed the flames, so that they spread with unusual rapidity. The fire marshal, however, was of the opinion that the house could have been saved if the alarm had been given when the first attempt to telephone was made.

Mr. Sanislo has some interesting comments on the fire and we quote from his letter as follows: "Enclosed find some clippings that will interest you as a danger that every community has in the form of phone hog, who may be the cause of just such a fire elsewhere, especially where there are party lines. It would seem that in just those communities where they have little or no fire protection with this type of phone installed in the neighborhood the people would heed a request to hang up and allow the transmission of an alarm of fire.

"No doubt there have been such requests for the use of the phone only to have the other party hang up, and like the wolf story in the fables, they simply were not going to be fooled again. Mr. Bringhurst, fire marshal, has gone the limit to find some way of pressing a charge, but so far there is no law that can reach such persons."



Drawn by Paul Reilly

What To Do in an Emergency

If your house catches fire — Run to the telephone — Try your best to get the Operator — And stay around to do what you can for the firemen

*Courtesy of Judge Copyright*

# The Great Boston Fire of 1872.

Recent research on the general subject of city conflagrations has disclosed some interesting matter relating to the great Boston fire which occurred a half-century ago next year, following the historic Chicago fire of the preceding year. A particular article by Mr. James M. Bugbee, a member of Boston's first police commission, (whose son, Percy Bugbee, has present charge of the fire records of the N. F. P. A.), which appeared in the *North American Review* for July, 1873, indicates the character of the Boston fire department at that time and its utter inadequacy in meeting the situation with which it was confronted.

Certain of Mr. Bugbee's observations on general conditions have a most modern sound. For example this paragraph might have been written yesterday:

> Our modern inventions appear to have left us where we were in the beginning. The new forces brought into operation for putting out fires are neutralized by the increased facilities for the spread of fire. The large cities in this country have grown up without any restrictions in regard to the construction of buildings; and it is within the last half-dozen years only that municipal governments have considered that they had any concern in the matter. Since the insurance offices have taken everything under their protection, from a granite warehouse to a lady's wardrobe, and paid fire departments have been organized, the sense of personal responsibility in the protection of property from fire no longer exists. This is seen in the reckless manner of constructing buildings, and in the general neglect of all precautionary measures.

There has been in the past fifty years a marked improvement in the fire resistive quality of the better classes of buildings, but in some respects the strictures of the above paragraph are still deserved.

A study of the Boston fire department indicates that even after the great conflagration the politicians in the city council did not seek any improved form of organization or administration of it. Politics had become so intimate a part of fire departments under the old volunteer system as to be carried naturally into the paid departments where they were organized. In a number of the large cities after the Chicago and Boston conflagrations the departments were placed under the control of a board of commissioners appointed for a term of years and an effort made to get rid of political influences. Not so in Boston. Boston continued to elect the chief and his fourteen assistant chiefs by vote of the city council. The mayor appointed all other members of the department with the approval of the aldermen; but the city council controlled the number of firemen to be appointed, designated their qualifications, terms of service and duties, and provided and located all the fire apparatus.

During a fire the chief and his assistants were given full authority, but they might be placed in such a position by previous action of the city council in locating the apparatus and in establishing the regulations under which their subordinates should act, as not to be able to exercise this power with any efficiency. This is made sufficiently clear by Mr. Bugbee's description of the department at the time he wrote, the year after the fire.

He says:

Under the authority to fix the qualifications of members, the City Council provides that every foreman and assistant foreman of a company shall be nominated annually, and whenever a vacancy occurs, by the members of the company. It often happens that the man who has held the position for years, and who is best qualified for it, is thrown out by a bare majority of disaffected members, and one who is totally inexperienced put in his place. The regulations give this man the power to direct the placing of the engine at fires, and the charge and control of the hose and hose-men.

An engine company consists of a driver, a fireman, and an engineer, who are permanently employed, and eight hose men, (including the foreman), who do duty only in case of fire and who are engaged at other times in various private employments. A hose company consists of a driver, who is permanently employed, and eight hose men, including a foreman. The hose companies act independently of the engine companies. When a fire is below the third story of a building, they connect the hose with a hydrant; when it is above, they connect the hose with an engine. A hook and ladder company consists of a driver, permanently employed, a foreman, an assistant foreman, four axe men, four rake men, and from six to thirteen ladder men. The crew of the steam fireboat, attached to the department, consists of a captain, an engineer, and five assistants, all permanently employed. The duties of these men are sufficiently indicated by their titles. The whole force, including the engineers, consists of four hundred and fifty-nine men.

With the exception of the engineers, the men continue in service during good behavior. Although the foremen and assistant foremen may be reduced to the ranks by the action of the companies at their annual nominations, they cannot be deprived of membership. The annual election of engineers by the City Council has a very pernicious influence upon the discipline of the department, not so much on account of the changes which are made,—as the old members are generally re-elected,—but on account of the state of subserviency which results from their dependence upon a political body. Assistant engineers are put in nomination against their chief; foremen of engine companies enter into political competition with the assistant engineers; and the members of companies intrigue for the nomination of foreman. It would hardly be expected that such an organization could enjoy a high state of discipline. The surprising part of it is, that there should be any discipline at all. Neither the officers nor the men have any training, except that which they receive while attending fires.

It would hardly be possible to devise a more ingenious scheme for dividing responsibility, and insuring the largest possible outlay, than that adopted by the City Council for the government of the fire department. There is a joint committee of the City Council on the department, a board of engineers, another joint committee on fire alarms, a superintendent of fire alarms, another joint committee to purchase lands and erect and repair station houses, and another board which locates and controls the hydrants and reservoirs.

Considering the training of the department there is of record a very interesting letter written by E. M. Shaw, chief officer of the London Fire Brigade at that time, who had visited America some years previous to the Boston fire. It will sound to our fire department members who have worked so zealously for the establishment of fire colleges and drill schools a good deal like their own arguments. Captain Shaw says:

When I was last in America, it struck me very forcibly that, although most of the chiefs were intelligent and zealous in their work, not one that I met even made a pretension to the kind of professional knowledge which I consider so essential. Indeed, one went so far as to say that the only way to learn the business of a fireman was to go to fires,—a statement about as monstrous and as contrary to reason as if he had said that the only way to become a surgeon would be to commence cutting off limbs, without any knowledge of anatomy or of the implements required.

There is no such short cut to proficiency in any profession; and the day will come when your fellow-countrymen will be obliged to open their eyes to the fact, that, if a man learns the business of a fireman *only* by attending fires, he must of

View from Washington St. after the fire.

View from Milk St., opposite the Post Office, where the N. F. P. A. Executive Office is now located.

*Courtesy of Bostonian Society*

necessity learn it badly, and that even what he does pick up, and may seem to know, he will know imperfectly, and be incapable of imparting to others.

I consider the business of a fireman a regular profession, requiring previous study and training, as other professions do; and I am convinced that where study and training are omitted, and men are pitchforked into the practical work without preparation, the fire department will never be found capable of dealing satisfactorily with great emergencies.

It was with such political influences emasculating it and with practically no training but rule-of-thumb that the Boston fire department went up against the big fire of 1872. The department was not then even as efficient as when described by Mr. Bugbee in 1873, for the fire boat and its crew for protection of the water front was not added until after the conflagration. Mr. Bugbee's description of the fire is as follows:

"The fire of the 9th of November originated in the basement of a warehouse about seventy-two feet high, including a Mansard roof, and covering an area of fifty by one hundred feet. The front wall was of granite, the rear and partition walls were of brick. The building stood at the corner of two streets,—one of the streets being forty-five feet in width, and the other forty feet. On the opposite sides of these streets there were buildings of about the same height, crowned by wooden Mansard roofs.

There was a fatal delay in giving the alarm. It being Saturday, the wholesale stores closed at an earlier hour than on other days. At six o'clock this section of the city was almost deserted. At that hour all the police officers in the city were withdrawn from the streets, to attend the roll-call at their stations. Two Charlestown officers testify to seeing the fire from a point at least a mile and a half distant at about ten minutes past seven o'clock. They established the time by a railroad clock. A number of other persons saw it between fifteen and twenty minutes past. The police officer on whose beat the fire occurred was chasing some boys who were making a disturbance in the street, when he came in view of the fire, which was then "streaming from the top of the building." There was an alarm-box right at his hand, and he stopped and gave the alarm on the instant. The operator on duty at the central office started his instruments immediately, and looked at the clock in order to make his record. It was twenty-four minutes past seven.

One steam engine and one hose carriage started for the fire just before the alarm sounded, having received notice by the cry of fire in the streets. The engineer of the steamer testified that he had a stream on the fire in four minutes after the bells struck. The engineer of the second engine testified that he played two streams inside of ten minutes from the time the alarm was given. A member of the first hose company which arrived testified that his company got a stream on the fire about five minutes after the alarm, and about six minutes before the first engine played. An assistant engineer living near by "heard somebody hallooing fire in the street," and looking at his clock saw that it was eleven minutes past seven. He went immediately to the fire, and arrived there in advance of any fire apparatus.

The epidemic which prevailed among the horses at that time throughout New England caused some delay in getting the engines and ladder companies to the spot; but the delay on this account was not so serious

as many have supposed. The temporary loss of horse-power had been made good in a great measure by the addition of five hundred men to the force, who were paid one dollar each for assistance in dragging the apparatus to a fire, and twenty-five cents an hour for the time they served. The nearest engines responded about as quickly after the alarm as they would if the horses had been fit for duty. Those at a distance were delayed from five to forty minutes. There is a vast amount of conflicting testimony upon this point of the delay in giving the alarm, and the delay after the alarm was given, in getting the fire apparatus on the spot and into operation. It would be safe to say that there was a delay of at least fifteen minutes after the fire was visible at a considerable distance, before the telegraphic alarm was given.*

At half past six a single bucket of water would probably have been sufficient; an hour later, and the whole force that could be mustered was insufficient. As police officers, all of whom were supplied with keys to the boxes, were expected to give the alarms, although duplicate keys were deposited in shops or houses near by, those who first saw the fire took no steps to ascertain whether an alarm had been given, but stood enjoying the sight, and speculating upon the failure of the engines to arrive.

The fire appears to have started near the bottom of the opening for the elevator, which extended from basement to attic. As soon as the flames entered this opening, they were carried up with tremendous force, and burst through the roof in an incredibly short time. The building contained about $250,000 worth of dry goods, some of the articles being highly combustible. The foreman of the first hose company which arrived testified that the rapidity of the fire was beyond anything he had ever seen during an experience of twelve years in the department. An engineer of one of the engines said,—

> When I arrived there (six or seven minutes after the alarm), the whole rear of the building was on fire, and the upper stories both front and rear. The flames were coming right out fifteen feet. They would almost go across the street. I stayed there as long as I could. The chief told me to stay there until it burned the gauge-cocks off, and I stayed as long as I could stand it.

The chief said,—

> In my experience in the Boston fire department, covering twenty-five years, I never saw such a sight as was presented that night: within eight minutes from the time the alarm sounded, I was on the ground, and the building was literally consumed. With all the fires we have had in that district and other sections of the city, I never saw the time, no matter how inflammable the building was, whether it contained oils or any other inflammable material, but what we could enter the building itself; but here was a case where you could not get near the building. The material of the building being granite, its explosive properties were shown very conclusively by the shower of granite that was flying in every direction, from pieces weighing one pound to ten and twenty.

* The Chicago fire was discovered by a policeman when it was so small that he thought it best not to sound an alarm. He tried to extinguish it himself, but failed, and then notified the nearest steam-engine company. The engine was placed in position at a hydrant about five hundred feet from the fire, and it required all the hose on the reel to reach it. In the meantime, sparks from the building originally on fire had caught in some tenement-houses, too distant for this first engine to reach with its streams. An interval of twenty minutes had elapsed since the fire was discovered when the watchman at the City Hall, half a mile distant, saw the light and sounded an alarm. This called three additional engines, the chief, and one assistant engineer. The second and third alarms were then sounded, which called out the full working force of the department.

It was a bright moonlight night. The velocity of the wind was from five to nine miles an hour. But, as the fire went on, the induced currents of air in the vicinity were very strong; so that those who stood in the streets near by supposed there was a great windstorm prevailing.

According to the returns of the engineers, there were seven steam engines on the ground within fifteen minutes from the time the alarm was sounded; and the whole department reported for duty within an hour and thirty minutes. These returns are probably quite incorrect, as, in most cases, the time given was only guessed at, and the officers were all interested in making as favorable an exhibit as possible. The distribution of fire apparatus throughout the city had been made by the City Council, without any regard to the great bulk of property to be protected. In the old portion of the city, where the assessed value of property amounted to $514,697,450, there were only six engines; while an outlying ward, having an assessed value of $31,395,300 had an equal number. In the whole district covered by the fire, containing more perishable property than any other portion of the city of equal extent, there was not a single engine or hose carriage.

The officers who first arrived attempted to fight the fire in the building where it originated; but, finding that impracticable, they gave their attention principally to the buildings adjoining, on the southerly and easterly sides. It would appear from the evidence that the engineers, as they arrived, took charge of the first engine or hose company that they came across and went to work. It was just here that the professional training which Capt. Shaw insists upon would have enabled these men to comprehend the emergency, and take measures to meet it. They entered upon the contest without any plan, without any concert of action even. Instead of stopping to consider calmly where an effective opposition could be made, they took up positions from which they were driven by the heat of the fire before they could get to work. It was an extraordinary fire, but the engineers proceeded to fight it in an ordinary way. In the course of the next hour the fire made such progress, that it is doubtful whether any man or any body of men could have checked it with the means then at hand.

Aid was furnished very promptly from other cities and towns; and, in five hours after the alarm was given, there were fifty steam engines on the ground, besides several hand engines and a large number of hose carriages. Here was a very powerful force, but for various reasons it could not be utilized for a considerable time. The hose and hydrant couplings were of different sizes, and there was a good deal of delay in making connections. The supply of water was insufficient. The district over which the fire was then spreading was covered a few years previously by dwelling houses from two to four stories in height. These small houses had given place to great warehouses from sixty to ninety feet in height, filled, in most cases, with combustible materials. The small six-inch water pipes originally laid in the streets had not been changed. They had become reduced by rust to about five inches in diameter. The engines which drafted from hydrants near the large mains reduced the head so that those drafting near the fire could not play a stream above the second or third stories of the buildings. No change had

been made in the old-fashioned hydrants. They were placed in the sidewalks, and supplied by a small branch from the street pipes, so that, unless there was a heavy pressure on the street pipes, these hydrants were almost useless. There were a number of reservoirs located under the principal streets, having a capacity of about four hundred hogsheads each; but as they were fed by the same pipes which supplied the hydrants, they were soon exhausted, or reduced so low that they could not be made available.

The appalling rush of the flames, the falling walls, and the short supply of water, all tended to discourage the firemen. Dr. Henry J. Bigelow, in his testimony before the Commission, said:—

The obvious thing through the night was the utter inadequacy of the means to the end. The thing that I noticed, wherever I saw the engines and the fire, was that the streams failed to reach the upper story. They broke into spray, and seemed wholly ineffective at that height. The second thing was that, I should say, half the streams seemed to be playing at the intervals between the windows, as if aimed at nothing; or, to give an illustration of it, as if the firemen were tired, and had got to do something, and it did not seem to be of much use to play into a window; and so, as the water was coming, they just let it go. Occasionally there were spasmodic efforts to wet the opposite houses, but apparently they were soon abandoned. Occasionally hose was taken to the top of a store to play on the next store, but for some reason that was also soon abandoned. I suppose the firemen were roasted out. The radiated heat was immense at a distance,—I mean against the wind. Another thing noticeable through the night was the number of unemployed engines to be seen standing at corners. Another thing I noticed was the way the fire caught from one building to another. A strong party-wall seemed to be the best protection. But when one store was pretty well burned, the upright roof of the next one (for they were most all of them French roofs) began to smoke at a dozen or so small points between the slates. After a while, a few little tongues of fire appeared here and there.

Before the slates gave way, these little tongues of fire were coming out between the slates; here fire, there smoke, and tongues of flame everywhere. Then came the flame, perhaps not larger than your finger or your wrist. Presently, somewhere a place as big as your head was burned through, and then the whole roof was on fire. Within a very few minutes the story below the French roof showed fire at the windows. Then quite an interval elapsed, and the fire broke out simultaneously from many windows at once, as if the ignition had been impossible from want of air, until the windows were broken, when the whole burst into flames.

President Eliot of Harvard College, who happened to be in the vicinity, and who went to the fire soon after the alarm was given, said:—

The thing I noticed most that night, up to twelve o'clock, was that water was not put on the fire. The great bulk of the water was thrown on to the vertical walls of those granite and brick buildings. The water didn't go more than three stories high, as a rule; sometimes it went a little higher, but seldom more than three stories high. It then fell down in front of the building, across the sidewalk, and went into the street. The hose men didn't break the windows, as a rule, and the water, therefore, didn't penetrate the building at all. I, over and over again, saw powerful streams of water used in that way, where the upper stories and roofs of the building on which they were playing were in a light blaze. I saw it repeatedly during that night, and as late as eight o'clock on Sunday morning . . . That was the most astonishing thing during that whole night, to see Americans using resources in that way. I would not have believed it; nothing would have induced me to believe it . . . It seems to me that there were two defects of organization that were pretty conspicuous. One was, that the chief engineer had apparently no means of commanding the whole field, and he had no means of sending orders. I saw him run two or three times across Winthrop Square in the course of fifteen minutes, carrying his own orders, and of course fatiguing

himself very much. He didn't seem to have any means of getting intelligence from the different parts of the field. In short, the fire department seemed to me to lack the methods of an army altogether, about receiving intelligence and conveying orders. Then, I couldn't but sympathize with the reluctance of the firemen to go on such high roofs. One reason was, that there were not firemen enough to handle the hose up those high buildings, and to station men all along the line, at short intervals, at a place of safety. I think hose men who are to go on roofs are entitled to that protection. They are entitled to feel that there are experienced men all along the line of hose on the line of retreat, who will warn them of danger and secure their retreat. It seemed to me there were not men enough attached to the hose and hose-carriages to do that.

On Sunday morning, when the fire had spread so as to enable the engines to draw directly from the large mains on Washington, State and Broad Streets, powerful streams were thrown to the tops of the highest buildings; and, if the Lowry hydrants had been attached, the supply would have been ample. There were men enough attached to the companies, if they had been properly managed. The number on regular duty that night, in the Boston department alone, was nearly three times as large as the regular force attached to the London department. But the engineers did not have their men well in hand. There was a great deal of wasted energy, and a good deal of straggling.

Between ten and eleven o'clock in the evening, the fire was making such rapid progress, and the ordinary appliances appeared to be so unequal to any successful opposition, that many citizens who had a large amount of property insisted on the use of powder. Of the conditions necessary to success in its use, they had no knowledge whatever. They had read in their school-books of the use of powder at the great fire in London; and they had heard of its use at great fires since that time, but of the manner in which it was used, and the results accomplished, they knew nothing. The chief of the fire department had made some investigations after the fire in Chicago, and had ascertained, that, in almost every instance, the use of powder for this purpose had been disastrous. In the hands of inexperienced persons, laboring under great excitement (the conditions under which it has generally been used at fires in this country), it could hardly be otherwise. In the present instance there were insuperable obstacles to success. The streets were narrow and very irregular. The buildings contained a large amount of woodwork, and were generally filled with combustible materials. It was clearly impossible to accomplish anything by blowing up single buildings, and the means were wanting to do the only thing that might, under certain circumstances, have been effective, namely, the levelling of all buildings between two streets running parallel along the whole front of the advancing fire.

A large number of excited individuals had gathered in the Mayor's office, as the alarming extent of the fire became known; and under the pressure of conflicting demands made upon him, the Mayor became as helpless and confused as the gentleman who held a similar office in London, during the great fire of 1666.* The chief engineer was summoned to the office, and induced, against his judgment, to give permits for blowing up buildings to a number of persons, most of whom were totally unqualified for the duty. They went to work in the most reckless man-

* "People do all the world over cry out of the simplicity of my Lord Mayor in general, and more particularly in this business of the fire."—PEPY'S DIARY.

ner; and it was not long before the firemen became alarmed, and threatened to withdraw unless the use of powder was stopped. As the gas had not been shut off in any of the buildings or streets, it escaped in large quantities from the broken pipes; and the combustible materials in the buildings caught fire as soon as the explosions occurred. Great clouds of smoke, impregnated with the escaping gas, rose high in the air, and exploded with the noise of bursting bombs, sending out tongues of flame which were seen at a distance of sixty or seventy miles. The radiated heat was so great that the thermometer in the observatory of the United States signal office, two thousand feet distant, and dead to windward, rose five degrees in the night.

On Sunday morning it was observed that the induced currents of air, which had been very violent during the night, were beginning to die out. This has been explained on the theory that the surrounding atmosphere is deprived of its oxygen faster than diffusion can replenish it. Four-fifths of the atmosphere, being carried up through the fire as inert matter, in the form of nitrogen and carbonic acid, is forced outward, and falling down, finally interposes a barrier of deoxydized air between the fire and the fresh inflowing air. Just at the time when the people were beginning to despair of saving their banking houses and public buildings, these atmospheric changes had begun to operate in their favor. The firemen found they were making an impression upon the flames. For the reasons already stated, the supply of water was improved, and a large number of streams, projected by the full power of the engines, were turned upon the fire. The permission to use powder was revoked, much to the chagrin of the gentlemen who were amusing themselves by the indiscriminate destruction of buildings. By four o'clock on Sunday afternoon the fire was under control.

During this short space of twenty hours, the fire had destroyed property of the value of seventy-five million dollars. If we take into account the time, and the small extent of territory covered (only sixty-five acres, including the streets), the loss was unparalleled by any fire up to that time. The rapidity with which the fire spread was due principally to the wooden roofs, which crowned the high buildings erected on narrow streets. There is no objection to the Mansard roof as constructed in Paris, where it is required, in all cases, that the walls should extend above the horizontal and the slope of the roof and be coped, and where the use of wood is never allowed, except for the inner plankings. Mr. A. C. Martin, in his testimony before the Commission, said:—

> Our architecture here in Boston has sprung from foreign architecture, which was carried out in stone; but it is so much easier to make a showy window in wood, and so much cheaper, that the owners were willing to do it, and architects, of course, were willing to produce an effect; so that, instead of the stone constructions which they have abroad on their roofs, and nothing else, we have great masses of wood, which become, in case of fire, very objectionable features . . . Then, I think, another reason why fire spreads so rapidly in our cities—I do not know that Boston is peculiar in that respect—is that we have timber very plenty. We put in our heavy floor timbers, three, four, and five inches thick, and fourteen and sixteen inches deep, and from six to twelve inches apart, as the case may be; then come the under floor on top of these timbers, and the upper floor on top of that; then the walls are furred and lathed and plastered, making all the floors and the furring on the walls open, so that the air passes freely through; and, in case of

fire, these spaces become conductors, the currents pass through very freely, and fire is communicated very rapidly, especially in an upper direction.

In Liverpool, previous to 1843, the large warehouses were built with continuous roofs, and with wooden doors and penthouses to the different stories. As a consequence, enormous losses were sustained when a fire occurred, and the rate of insurance went up from eight shillings per centum to thirty-six shillings. The building law was amended, so as to require the erection of party-walls five feet high between each warehouse; doors and penthouses were constructed of iron; the cubical contents of the buildings were limited; and the result was soon shown in the reduced rates of insurance.

It was customary in America in 1873 to designate buildings constructed of stone and iron as "fire-proof" without taking into account the tests to which these materials might be subjected, or the purposes for which the buildings were to be used.

Then, however, as now, there was intelligent opinion on the subject of the fire-resistive character of these materials and the slow burning and insulating qualities of wood. In a book called "Fire Surveys," by Chief Shaw of the London Fire Brigade, who is referred to above, and of which an American edition was brought out in 1872, Chief Shaw says:

It may be laid down as a rule that, of all building materials, stone is the least able to resist the effects of fire.* It may be safely used for walls, because in that case it is supported throughout; or it may be used for stairs, provided that they are built solid, but for stairs in the ordinary sense of the word, that is to say, steps with one end pinned into a wall, and the other end hanging and unsupported, stone is a most dangerous material to use.

And this paragraph appears among others of similar interest in the *Practical Magazine* of January, 1873:—

Wherever iron is used, it should be protected either by good brickwork, sound plastering, or, if nothing better can be found for the purpose, solid wood-work round it. Wood-work if really sound and solid, will resist for almost any length of time every possible effect of heat short of actual flame; even when flame has reached it, it is by no means destroyed at once, but on the contrary is sometimes found to last for hours; and wood protected on its under side by proper plastering which will not fall down or crack on the application of heat seems to be a most powerful resister of flame.

The slight resistance which the pretentious granite fronts offered to the progress of the fire in Boston was doubtless owing in a great measure to the fact that the walls were, in most cases, constructed of different materials, bricks of an inferior quality being concealed behind a thin covering of ornamented granite or freestone. The difference in the ability of the materials to withstand the effects of fire naturally caused a sep-

* "Granite is not so likely to resist the action of intense heat as some of the other building stones, such as limestone, sandstone, and indurated argillaceous rocks; and, in my opinion, the cause of the destruction of buildings composed of granite, the crumbling and 'blowing up' which has lately been observed in Boston, whilst brick buildings have escaped with comparatively little damage, is owing to the fact that granite, being composed of a number of crystalline minerals, one of these having cavities, the majority of which are filled, or partially filled with water, on the application of heat so intense as that of the Boston fire, would generate steam or inflammable gas to such an extent as to blow the particles of which the stone is composed into fragments; in fact so as to utterly destroy its integrity, and leave nothing but a crumbling mass of ruins. Any one at all conversant with the explosive nature of steam will readily see that each crystal would be similar to a boiler without a safety-valve, being subjected to intense heat, the result being, of course, that, as the heat becomes generated, without the possibility of escape, the boiler must burst, and that the brickwork (in the case represented by the other minerals of the granite) incasing the boiler, must inevitably be rent asunder."—E. HENDREN.

aration of the parts. If these walls had been built entirely of stone or entirely of brick, they would have been much safer. Another cause of the rapid spread of the fire is to be found in the fact, that many of the buildings had skylights, constructed with light wooden frames. The burning brands from the fire, falling upon these fragile coverings, broke through; and buildings situated a considerable distance from the main body of the fire suddenly burst into flames, and led the firemen to think that incendiaries were at work. Most of the buildings contained open hoistways, extending from the basement to the attic, which made it impossible to confine the fire to the story in which it started.

Anybody reading this story of the Boston fire must detect in it the same elements of hazard with which the N. F. P. A. is still struggling: bad building construction, politics in fire departments, lack of firemen's technical training, delay in transmission of fire alarms, non-standard hose couplings, too small water mains, unintelligent use of explosives, insufficient control of gas mains or supply and all the minor elements and unforseen and often baffling circumstances that beset the fighters of a sweeping fire once under way. The first and final answer to it all is the protection of horizontal and vertical openings in buildings that may contribute to or spread a conflagration and the protection of such buildings by the automatic sprinkler.

# The Sprinkler Head--"Poetical."

## From An "Unmetred Supply."

**(Member N. F. P. A.)**

An able historian aptly describes the automatic sprinkler as "the most important fire protection device ever invented." Those who have watched its record for many years hold it in affectionate regard, and unlike most inanimate objects, it responds ef-*fuse*-ively to a warm greeting. Sentimentality over the automatic sprinkler, however, may lead to a serious doubt of the author's sanity. It likewise becomes difficult to express one's ideas. Christopher Morley has put this thought in poetic form.

**Caution.**

My mind needs no fire escape
It is equipped with automatic sprinklers.
As soon as an idea catches fire
They put it out.
I am heavily insured against
Inflammatory notions.

Even poetic license, and such a delicate tribute to the efficiency of the automatic sprinkler, would not countenance the discontinuance of our committees on Safety to Life and Inflammable Liquids. Nevertheless, there has been a considerable wooing of the poetic muse on behalf of the humble sprinkler head, as gleaned from the technical and advertising press. While the "soul" of the poetry, to reverse the usual expression,

may suffer from its relation to a commercial article, there are clever contributions. The author's is an "extra hard head" in an endeavor to provide the "releasing mechanism" for a "fitting" "frame" to "yoke" these various poems into a harmonious "body." The "compression screw" will therefore have to be "tensioned" and the "cap" applied through the editor's blue pencil, otherwise, the reader may imagine the "distribution" by the "deflector" is from an unfailing and unmetred high pressure supply. In conventional, and not sprinkler head, terms it is meant space will not permit including all of the poetry at this time.

Childhood's happy hours are recalled in the paraphrases:

**Little Drops of Water.**

Little drops of water
From a sprinkler quaint
Make the ugly fire-bug
Look as if it ain't.

**The Fire to the Sprinkler.**

Sprinkle, sprinkle little head
How I wish that you were dead,
Up upon your perch of pipe
You douse me before I'm ripe.

**The Little Flame and the Fire Demon.**

"Father may I go be a fire?"
"Oh yes, my darling 'crinkler,'
Light yourself on a circuit wire
But don't go near the sprinkler."

War's alarms loom again in:

**Strafe You, Leedle Springler Plug.**

Curses on you Springler Head,
How I vish dot you vas dead,
I can't burn out Uncle Sam
Ven you are on der job by tam.

I fill dos plants mit dyn'mite stick
Und get all fixt to turn my trick,
A leedle fire, you start to splash
Und make my plans all into hash.

I tink I'll burn up all der wheat
Und bring dot country to my feet,
But you are always on der guard
Und make my burning job too hard.

So strafe you leede Springler Plug
I vould like to smash your mug,
My arson jobs dere not much goot
Ven in my plans you shove your snoot.

Jingle rhymes are present in:

In every town there is a man,
Whose mind you cannot turn;
He is so doggone cussed sure
His buildings will not burn.

But when some dark and stormy night
His plant goes up in smoke,
Says he, "Well, now I am quite sure
That sprinklers are no joke."

**The Sprinkler's Like —?**

The sprinkler's like a whiskey jug,—
A fine thing to behold,
But under the cork as snug as a bug
Must be stuff that is wet and cold.

A more literary effort is:—

THE DEMON.
[WITH APOLOGIES TO KIPLING]
A fool there was and he placed his all
(Even as you and I)
In the sticks and stones of a building tall;
(We called it the place where fire would fall)
But the fool he called it his "fire-proof" mall.
(Even as you and I)
Oh, the wealth we waste and the health we waste,
And the value of buildings and land
All go to the Demon who did not care
(And now we know that it never could care)
And never could stay its hand.
A fool there was and his goods he spent,
(Even as you and I)
Honor and faith and a sure intent,
(In the very place where the Demon went)
But a fool must follow the precedent.
(Even as you and I)
Oh, the toil we lost and the spoil we lost!
And the excellent future planned
Went up in the smoke of the Demon's spite,
(And now we know of that Demon's might)
Who could not stay its hand.
The fool was stripped to his foolish hide,
Which the Demon saw by the ruins' side;
(But it isn't on record the Demon cried)
So some of him lived, but his business died.
(Even as you and I)
And it isn't the shame and it isn't the blame
That gives to the fool his brand;
It's coming to know that the Demon's might
Could have been checked in the stilly night
And made to restrain its hand.

Probably the best known poem on the sprinkler head is that by our member, Paul Mason, and entitled "The Beheaded Sprinkler."

**The Beheaded Sprinkler.**

A sprinkler sat on his pipe, alone,
Like a shabby king on a shabby throne;
The room was dark—at the foot of a stair—
And few there were that saw him there;
His head was gray with the dust of years,
But he held his peace—and his pent-up tears.

Day followed night, and the night the day,
And things went along in the same old way.
There were few who passed through his throne-room dim,
And fewer still who regarded him;
But he held to his pipe, nor worried a mite—
He knew his job, and stuck to it—tight.

Then one day came a wisp of smoke—
A tongue of flame—and like hammer stroke
He leaped to the job that he knew was his;
A pop, a splash, and a dying fizz—
The flame was gone and the fire was dead,
But the sprinkler had lost his hoary head.

"After all," said he, as they took him away
"I stuck to the job till I had my day;
I knew my task, and there I stayed,
To call the bluff if 'twas ever made.
'Tis better by far than a dozen dead
That I should have stayed till I lost my head."

In some respects, the sprinkler head does compare with the human head, in other respects, the contrast is marked. It is mainly "upright"; it gets "hot" before the cooling liquid passes through its orifice; it sometimes foams at the mouth; its characteristics may be entirely changed through adverse circumstances; advancing age darkens but does not whiten, probably due to the absence of grey matter in its top; it stays up all night and every night without affecting either its size or feeling. In its crowning achievement, however,—the extinguishment of fire—the noblest attribute of mankind is emulated, in that it sacrifices itself to save others.

The closing contribution by Franklin P. Adams infers calamity by fire due to the absence of the automatic sprinkler. It is a striking characterization of the usual result of investigating preventable disasters and is therefore included.

**"Cui Culpa?"**

A train collision killed a few; "investigation" came;
The "probe" was sharp, the "probe" was deep, but "no one" was to blame.
The overworked dispatcher, true, had fallen fast asleep,
But that was not the railroad's fault—and the "probe" was sharp and deep.

A hundred souls, a thousand souls were sacrificed to flame;
The "probe" was long, the "probe" was deep, but where to "fix the blame?"
"'Twas panic killed the audience; the loss of life was due
To trepidation of the mob," said Twelve Good Men and True.

Pray God we grow not bitter, but it makes the vision red—
This hellish truth of crushed-out youth, this tale of needless dead!
No single name shall bear the blame, go "probe" ye ne'er so deep,
For the Cost of Living rises high, but the cost of life is cheap.

# The Protection of Historic Public Buildings.

## 1. Independence Hall, Philadelphia.*

Philadelphia has been fortunate in safely preserving old Independence Hall which dates back to 1732, and is famous as the building where the Declaration of Independence was made, where the Constitution of the United States was signed, and where many other important historical events have taken place. As has been the case with historic public buildings in other cities, until recently no action has been taken towards preserving this national monument from fire. During the restoration work started in 1897 some cognizance of fire hazards was taken by the City of Philadelphia, and in the work now authorized further steps are being taken to make the building as safe from fire as possible without modifying too radically the original style of construction. In the days when Independence Hall was constructed there was, of course, no thought of fire protection, the original timbers and other wood work now seasoned and dried by time would make excellent food for flame, and on this account the problem of fire protection is not a simple one. For the work now being undertaken Mr. Stewart A. Jellett (member N. F. P. A.) is the consulting engineer for the fire protection features, and it is to Mr. Jellett that we are indebted for the data and illustrations used in the preparation of this article.

### Historical.

A brief historical sketch of Independence Hall, taken from "A Short History of the Independence Hall Group of Buildings," issued for distribution at the National Museum, is given as being of general interest in connection with the building.

In May, 1729, after the Provincial Assembly of Pennsylvania had been compelled to "hire a house annually" in which to hold its meetings, "the House took into consideration the necessity of a House for the Assembly of this Province to meet in, and it was unanimously resolved that £2,000 of the £30,000 then to be emitted in paper currency should be appropriated towards building such a House."

Andrew Hamilton, a member of the Assembly, was the architect who designed the building. He, as one of a committee of three appointed to select a site and put up the building, authorized William Allen, a prominent merchant of Philadelphia, to buy, in his own name for the use of the Province, the first piece of ground necessary. This was in 1730, and by 1732 Hamilton succeeded in getting the balance of the ground needed. In the spring of 1732 ground was broken, and Independence Hall begun.

The first public use to which any portion of the building was put was for a banquet to the citizens of Philadelphia by Mr. Allen, who was then

*Note. This is the first of a series of articles on the fire protection of important public buildings of historic interest. The second article will appear in the October Quarterly.—Ed.

**View of the State House Row (Independence Hall Group) showing the original tower construction, wings and arcades before Congress Hall and Old City Hall were erected. From a drawing made in 1778 by C. W. Peale.**

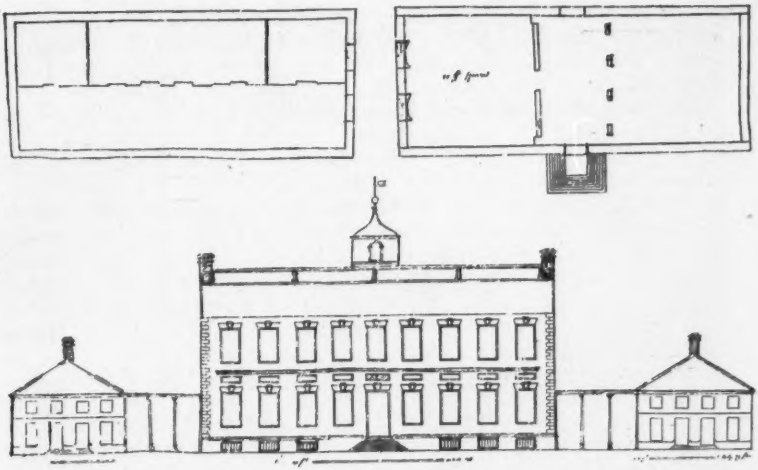
mayor. This banquet was given in September, 1736, in what has ever since been known as the Banqueting Hall.

The first occupancy of the State House by the Legislature was in October, 1736, when Andrew Hamilton was elected speaker for the seventh term, and Benjamin Franklin was clerk. The building was still unfinished in 1741, and in the summer of that year the Assembly insisted that at least the plastering and glazing should be finished for the next session, and that "the whole building with all its parts should be finished without delay."

In 1750 the Assembly ordered the tower to be carried up, "to contain the staircase, with a suitable place thereon for hanging a Bell," and in June, 1753, Pass & Stow placed in position in the State House steeple a "new great Bell," weighing 2080 pounds, with this motto: "Proclaim Liberty throughout all the land unto all the inhabitants thereof.—Lev. xxv: 10."

On June 16, 1775, Washington accepted his appointment as General of the Continental Army in Independence Hall, and on July 4, 1776, the declaration of the Colonies that they were and of right ought to be free and independent States was made in the east room, now known as the Declaration Chamber.

The Convention to form a new Constitution for Pennsylvania met here in 1776. This Convention unanimously approved the Declaration of Independence.



**Photographic reproduction of original floor plan and elevation drawn on parchment by Andrew Hamilton, the architect.**

The American officers taken by the British at the Battles of the Brandywine (September 11, 1777) and Germantown (October 4, 1777) were held in the Declaration Chamber as prisoners of war.

Continental Congress, which had left Philadelphia in December, 1776, reconvened in the east room March 4, 1777; they left again September 18, returned July 2, 1778, and continued to sit here until the close of the Revolution.

On July 9, 1778, the Articles of Confederation and perpetual union between the States were signed in the Declaration Chamber by eight States. The five remaining signed later, the last (Maryland) on March 1, 1781.

The Federal Convention to frame a Constitution for the United States met in this chamber May 14—September 14, 1787, and, after final action and engrossing of the Constitution, those present affixed to it their signatures.

The Convention for the State of Pennsylvania ratified the Federal Constitution here on December 13, 1787. The Convention to frame the second Constitution of Pennsylvania, 1790, met in this chamber, also.

Congress Hall was begun in 1787 and finished in 1789. The City Hall Building was begun in 1789 and finished in 1791. Congress Hall and Old City Hall are the buildings appearing at the extreme right and left of Independence Hall in the illustrations.

The Congress of the United States occupied Congress Hall building from the beginning of its third session, December 6, 1790, until the seat of government was removed to Washington, in 1800.

Washington was inaugurated in this building for his second term as President of the United States (March 4, 1793), here he delivered his

farewell address to the American people and here John Adams was inaugurated on March 4, 1797. The House of Representatives occupied the lower floor; the Senate occupied the second floor; the adjoining rooms were used as committee rooms.

The Supreme Court of the United States held its first session on the second floor of the City Building, beginning February 7, 1791, and continuing until August 15, 1800. The Supreme Court of Pennsylvania sat on the second floor of this building also.

In 1812, Philadelphia got permission from the Legislature to remove a portion of the wings of the building, including the arcades, and to construct buildings for the public uses of the day. In 1816 the City of Philadelphia became the actual owner of the entire property. Several changes seem to have taken place at this time. Congress Hall was fitted up for the Supreme Court of the State, which since 1802 had been sitting in Independence Hall.

While the body of John Marshall, Chief Justice of the United States Supreme Court, was being removed from the house on Walnut Street, in which he died, to Virginia for burial, the Liberty Bell was ordered tolled in honor of the great jurist. This was on July 8, 1835, and it was while being thus tolled that the Bell became cracked.

The bodies of Henry Clay (1852), Elisha Kent Kane, the Arctic explorer (1857), and Abraham Lincoln (1865) were among those which lay in state in Independence Hall.

In 1854, the second story of the building was fitted up for the use of City Councils, which continued to meet there until 1895. The Mayor, Aldermen and later City Council sat in this building which was used until March 27, 1895, when the offices of the municipality were moved to the new City Hall.

In 1897, the central group of buildings was restored, and they are now kept as nearly as possible in their original state as a memorial of the year 1776 and its associations.

The building at the corner of Chestnut and Sixth Streets (Congress Hall) was restored in 1913, and the contract has just been awarded to restore the City Building at Fifth Street.

**Fire Protection.**

At the time of the original restoration in 1897 several points of fire protection were considered. At that time the metal roof was replaced with wooden shingles in order to give more nearly the effect of the original construction of the main building and wings. Before applying these wooden shingles, however, the roof was treated with two-inch, fire-resistive blocks carefully fitted so as to close off all possible openings. This same plan is followed in the other buildings of the group; Congress Hall and the Old City Hall, subsequently restored. The arched corridors appearing in the illustrations, which connect the wings with the main Independence Hall building are completely cut off by blank brick walls so that there is no possibility of spread of fire here. There is no basement under these wings, neither is there any basement under the tower or central portion of the main building.

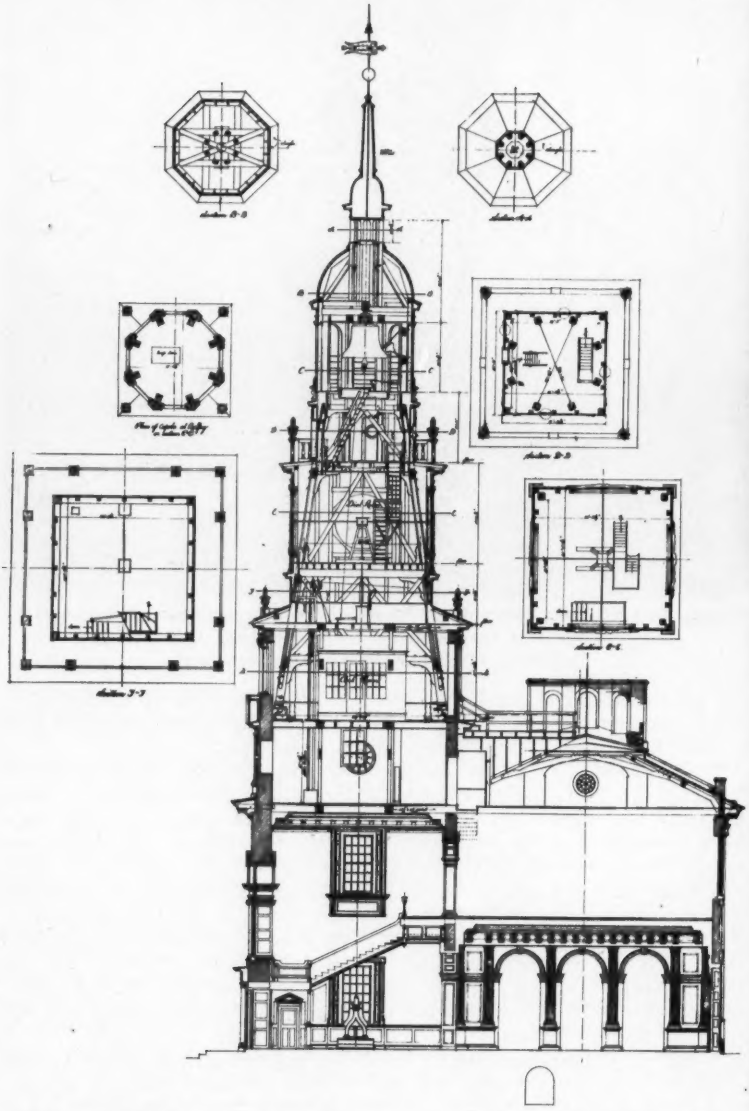
At the present time the most hazardous part of the structure is the tower super-structure which is all wood construction. It is planned to

**Independence Hall from Independence Square. This photograph was taken prior to the restoration when the metal roof shown here was replaced by old time wooden shingles laid over fireproofing.**

cut off this tower at the top of the present brick work by a substantial reinforced concrete slab. Other features of the fire protection work now contemplated are described by Mr. Jellett as follows:

The matter of the restoration of the Independence Hall group of buildings to the condition existing at the time the Declaration of Independence was signed has been under very careful study for some years by a Committee of the American Institute of Architects of which committee Mr. Horace Wells Sellers of Philadelphia is the chairman. Independence Hall, the central building of the group, fronting on Chestnut Street and Congress Hall on the southeast corner of Sixth and Chestnut Streets, together with the East and West wings from Independence Hall have been restored and the City is about to place a contract for the restoration of Old City Hall, at the southwest corner of Fifth and Chestnut Streets. This will be the last building of the original group and will complete the restoration.

Mayor J. Hampton Moore has taken a great interest in seeing that these buildings are not only restored to their original condition, but also that every precaution shall be taken to preserve the buildings from loss by fire, and, therefore, in asking for the last appropriation for the restoration of Old City Hall to its original condition, an amount was included for fire protection. This included not only fire protection proper but



**Section through Independence Hall, looking west. From a measured drawing of the building made by the Philadelphia Chapter of the American Institute of Architects.**

**Independence Hall from corner of Chestnut and Sixth Streets. The building partially shown at extreme right is Congress Hall. The building at the left with the cupola is the Old City Hall. These two buildings are to be protected by cornice sprinklers; Independence Hall proper is not thought sufficiently exposed to require open sprinkler protection except on the wooden tower.**

also such necessary auxiliaries as remodeling of the heating systems, lightning rods and electric wiring, so that when the Old City Hall restoration work is finally completed, the group of buildings as a whole will be not only restored but amply protected.

The City of Philadelphia, while very proud of these historic buildings, realizes fully that it is a National Shrine and that it is incumbent upon the City of Philadelphia as the caretaker of this National Shrine to use every effort to preserve these buildings from injury or damage of any kind.

The work of carrying out these improvements rests with the Department of Public Works, and Mr. Frank H. Caven, the Director of this Department, together with the City Architect, Mr. J. P. B. Sinkler, and the Chief of the Bureau of City Property, Mr. Harry T. Baxter, have all taken a very great interest in this work.

There are at the present time heating boilers in Independence Hall, and Congress Hall, these boilers are to be taken out and no fires will be in any of the buildings. A new boiler room will be constructed underground in the rear of the Old City Hall; in which boiler room the heating

plant will be located and the handling of coal and ashes will be outside of the group of buildings and in a fire-resistive room.

The buildings are to be equipped with a special arrangement of lightning rods, plans of which were submitted to and approved by the U. S. Department of Agriculture.

After a very careful consideration it was decided to equip the basements throughout with a wet pipe system of automatic sprinklers; to install an electric driven fire pump in what was formerly the coal vault underground to the east of Independence Hall; to bring a new water supply main from the ten-inch main on Fifth Street, connect to this the fire pump and by-pass into the wet pipe system in basements of all the buildings so that city water pressure will be on these sprinklers at all times.

It is proposed to put in a dry pipe system of sprinklers through all attics with separate control from a header in the fire pump room. These sprinklers are purposely made dry pipe for fear of water damage by men working in the loft or making any repairs in the future, as the loft is immediately over rooms in which furniture and paintings of great historic value are exhibited.

As a further protection cornice sprinklers are placed around the Chestnut Street front and the Fifth Street side of Old City Hall and the Chestnut Street front and the Sixth Street front of Congress Hall; the wooden tower of Independence Hall and the smaller towers over Congress Hall and the Old City Hall. These cornice sprinklers are connected through a separate line controlled by a valve on the main header in the fire pump room.

By this arrangement, the caretakers themselves can handle any part of the apparatus from the fire pump room and the city firemen can do the same thing.

There is also an outside steamer connection by-passing around the fire pump so that if anything should happen to the fire pump or the electric current be shut off temporarily, the city fire engines can pump through the system or any part of it.

No cornice sprinklers are placed in front of Independence Hall or the East and West wings. The buildings facing Independence Hall proper, are all modern type bank buildings and do not constitute a fire hazard. Neither will open sprinklers be placed in the rear of any of the buildings, as this is a public park of considerable extent.

The only menace from outside is from the buildings at the corner of Fifth and Sixth and Chestnut Streets, and it is thought wise to put the cornice sprinklers on Congress Hall and Old City Hall as an additional protection against the fire menace from the opposite side of the street.

It is believed that with this installation of wet and dry pipe sprinklers, fire pump, outside steamer connection with the lightning rods on all the buildings and all fires out of the buildings, that every possible precaution has been taken to preserve this historic group of buildings from destruction or serious damage.

# The Boston High Pressure System.

**By John R. Murphy, Fire Commissioner.**

After ten years of delay since the original authorization, the Boston high pressure system is about to be put in service. The system in the city of Boston was authorized by an act of the Massachusetts Legislature dated April 20, 1911, but owing to needless delays by the authorities in preparing final plans and failure to supervise properly the work of installation very slow progress was made in the completion of the system in Boston. When Mayor Andrew J. Peters was inaugurated February 4th, 1918, strong measures were taken to perfect and complete the system.

The high pressure system is particularly necessary in Boston because of the conflagration hazard due to the narrow streets and the many old combustible buildings still existing in the high value district of the city. The introduction of the high pressure system will prevent as far as lies within human power such conflagrations in Boston as have occurred in some of our American cities.

The system, most modern in every detail, is designed to deliver water at a maximum pressure of three hundred pounds, from nozzles or special high pressure cars which carry their own hose. A plan of the system, and photographs of a demonstration of the high pressure apparatus accompany this article.

One of the sources of delay previous to Mayor Peters' administration was the continual changing of the location of the pumping station. The original plans called for one pumping station, and its location was changed some seven different times, which meant continued changes in the plan of the system and the various contracts.

The plan as decided upon by Mayor Peters substituted three separate pumping stations for one central pumping station, and located them as follows:

One at the Lincoln Power Station of the Boston Elevated Railway Company on Commercial Street, in which two steam turbine driven three stage centrifugal pumps, each of three thousand gallons capacity per minute, at three hundred pounds pressure, are to be installed. There will be three sources of water supply provided, one of which is from the salt water of the harbor. Steam is to be furnished by a battery of twelve water-tube boilers. There is also room for the installation of a third pump of three thousand gallons per minute capacity.

The second pumping station is to be at the station of the Edison Electric Illuminating Company on Atlantic avenue, opposite Pearl street, where two motor driven four stage centrifugal pumps, having three thousand gallons per minute pumping capacity at three hundred pounds pressure, are to be installed. The suction and discharge pipes of this station are to be similar to those at the Lincoln Power Station of the

Layout of the Boston High Pressure System.

Boston Elevated Railway Company. In addition to an arrangement of cables for supplying current there is on the premises a large storage battery sufficient to supply the power necessary for operating the pumps for a period of one hour. There is room for the installation of a third pump in this station.

The third pumping station is to be at the Stuart street sub-station of the Edison Electric Illuminating Company, where eventually will be installed two motor driven four stage pumps, each with a capacity of three thousand gallons per minute at three hundred pounds pressure. The suction and discharge arrangement at this station is similar to that at the other stations with the exception that salt water is not available. There is a large storage battery on the premises available for reserve use.

The work progressed with great vigor after the adoption of this plan by Mayor Peters. In July of this year two of the stations, namely those on Atlantic avenue and Commercial street will probably be completed. The total capacity of the system, when these two stations are completed as contemplated will be twelve thousand gallons per minute at three hundred pounds pressure, or approximately nineteen thousand gallons per minute at one hundred and seventy-five pounds pressure.

The capacity of the third station on Stuart street, when completed, will be approximately six thousand gallons per minute at three hundred pounds pressure or approximately nine thousand four hundred gallons per minute at one hundred and seventy-five pounds pressure.

On May 17, 1921, 11.3 miles of the distribution system had been laid, and there was approximately one thousand feet to be finished under existing contracts. When the third pumping station is installed the total mileage of the completed system will be 18.6.

The hydrants are believed to be the last word. After eighteen months of engineering study, exhaustive experiments with the various details of design. the building and testing of three different hydrants of the same general type, and a very successful fireboat test of the third design, the Public Works Department of the City of Boston finally adopted for its high pressure fire service the following type of hydrant:

The hydrant consists essentially of a pot or valve casing, barrel, head, hood or cover for the latter, main valve, auxiliary valve and four independent outside valves bolted to the head. This hydrant can be set closer to the curb line and occupies much less room than any other high pressure post hydrant of the same capacity. There are no sharp projections, nozzles, caps, etc., presenting an unsightly appearance and causing discomfort to pedestrians and sidewalk crowds. In general appearance, the assembled hydrant above the sidewalk is a pleasing contrast to the usual type of post hydrant.

In general, it is claimed for its construction, simplicity of design, reliability of operation, freedom from damage by abuse, and low friction losses. The hydrant was designed for a normal delivery of 2,000 gallons per minute. For the friction loss test a maximum of 3,000 gallons per minute was obtained and during the fireboat test over 3,600 gallons per minute (maximum capacity available) went through the hydrant.

Two 16-inch force mains and two 16-inch suction mains have been laid into the pumping station sites at the Lincoln Power House, Com-

**High Pressure Car.**

mercial street, and the Edison Station, Atlantic avenue, opposite Pearl street.

The four Venturi meters required for the two stations have been delivered and installed.

The Fire Department has had three special motor hose cars built, known as High Pressure Cars. They are adapted for the narrow streets of Boston, and are each capable of carrying two thousand feet of 3-inch

hose with 2½-inch couplings. On each car are mounted two deck guns. Each gun will furnish a stream of a maximum diameter of 2 5/8 inches, and at one hundred pounds pressure will deliver two thousand and forty-seven gallons of water per minute, in an unbroken vertical stream of 167.3 feet in height or an unbroken horizontal stream of 154 feet in length. The department will use 3-inch hose with 2½-inch couplings. A full supply has already been purchased with which to equip fully the high pressure fire apparatus, together with deck guns, nozzles, etc.

The high value district covers approximately one square mile in the business section of the city; the high pressure cars will be located in this area. The city of Boston covers approximately 47.81 square miles, and the portion of the area protected by the high pressure system is so situated as regards the rest of the city that in order to protect the city as a whole it will not be possible to do away with many of the motor pumping engines now in service in the high value district.

In order to control the pressure in the high pressure system to meet the requirements of the department when fighting a fire a signal system will be maintained by which messages can be instantly transmitted from the scene of the fire to the pumping stations. In each fire alarm box post in the high pressure zone a receptacle will be installed. These receptacles will be connected into special circuits which run to the fire alarm office. Each chief officer of the department will be supplied with a portable telegraph and telephone set, and upon arrival at a fire the chauffeur will connect the instrument into the receptacle by inserting a plug, and will be then ready to transmit any message which the chief officer desires to send.

A special circuit will also be run from the fire alarm office to the pumping stations, and upon receipt of a message from the chief at a fire, the operator in the fire alarm office will instantly transmit the message to the pumping stations.

All telegraph messages and time of their receipt will be automatically recorded on tapes, both in the fire alarm office and in the pumping stations. These automatic records are necessary in order to avoid any disputes that might arise regarding the messages sent. The telephones are for the purpose of verifying orders or for the transmission of unimportant messages.

All alarms will be received in the pumping stations on tapper and gong circuits, and upon the receipt of an alarm in the high pressure zone the pressure will be raised to 150 pounds and higher later if conditions demand it. All alarms and messages will be sounded on gongs, lights will flash the signals, and registers will record.

The Honorable Andrew J. Peters has been one of the most progressive mayors that has held the office. During his administration he has been called upon to meet some of the most abstruse problems of municipal government, and he has solved them correctly. Honor is due to him for what he has done as Mayor of Boston. In my opinion, however, he will be especially honored for what he did in completing the installation of the high pressure fire system, because of the difficulties he overcame and the great benefits Boston will receive as the result of his action.

# Switchboard Hazards.

Few of us realize the hazards that exist in our power plants due to faulty switchboards. In the rapid growth of stations during the past few years the safety of switching equipment has often been overlooked. There are many power plants in operation all over the country, with switchboards for 2,300 and 4,000-volt systems, which are entirely inadequate to properly perform the true function of a switchboard in case of an emergency. This unsafe condition has been brought about, first, by lack of engineering information regarding capacity of switches and the enormity of short-circuit currents on large generators, and, second, by power-plant owners being unable to secure the money to install switching equipment in keeping with the growth in plant capacity.

Regarding engineering information, there is now available considerable data that makes possible a reasonably safe switchboard under all conditions of short-circuited cables and busbars. To obtain proper safety the following points must be carefully considered: (1) Ultimate capacity of generators installed; (2) reactance of generators when all are operated in parallel; (3) proper location of external reactance to limit short-circuit currents; (4) selection of an oil switch which will open the circuit under the worst possible conditions, and (5) proper arrangement of the apparatus to reduce life and fire hazards.

Every power plant has its individual problems that should be gone into very carefully with expert engineers and with manufacturers of equipment. It is not intended to enter into these details, but to describe and point out present dangers and some of the remedies, especially considering stations that are operating switching equipment which is inadequate to meet an emergency. In many cases the point has been overlooked that any switch connected to a main busbar should have a rupturing capacity equal to the total short-circuit capacity of all generators in operation, or should be protected by reactors to within the limit of the rupturing capacity of the switch and, of course, should be protected by dependable relays.

### Accidents Resulting from Failure to Provide Larger Switches.

In the past few years many stations of comparatively small capacity have made additions of large generators and connected them to the existing switching equipment, and in many cases have "gotten by" with no serious results. But in other stations serious fires and accidents have occurred. As long as service is satisfactory, and until an accident occurs, we do not realize the dangers that exist. Just recently this was very forcibly brought to attention at a property in Indiana. In this instance an oil switch short-circuited and blew up, killing two men and destroying by fire half the bus

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Paper presented before Illinois State Electric Association, as reported in the *Electrical Review*.

structure and a quantity of cable and damaging several motor-generator sets. Property damages amounted to approximately $40,000. Had the repair men and operator realized the danger and had sufficient fear of results, the loss of life and most of the property damage could have been avoided.

The station capacity in this particular case is about 20,000 kw., the largest unit being rated at 10,000 kw. This is one of the cases referred to above where the old switching equipment was retained and large machines added to the plant. The switchboard proper is located on the main floor, with the bus structure in the basement. The switches are mounted in the usual brick and concrete compartments, and the busses are mounted about 4 feet above the cells and spaced about 8 inches between centers, with no compartments or barriers, and are completely taped up with cambric and friction tape. This taping was done to protect men while working in the switchroom, but increased the fire hazard to a considerable extent by adding to the combustible material.

At the time of the accident one 10,000-kw. turbine was in operation and a 4,000-kw. unit was being synchronized. The switchboard operator had pulled the closing button three times and the solenoid-operated switch failed to remain closed. He reported the condition to the station electrician, who entered the switchroom below with a helper. The turbine switch had been blown open and oil was on the floor, and there was some fire in the switch compartment. The electrician and helper proceeded to pump carbon tetrachloride extinguisher liquid onto the fire. In a few minutes there was a violent short-circuit and an explosion of burning oil which saturated the clothing of the two men. The station electrician was an experienced man, but in his efforts to save the plant and avoid an interruption of service he did not realize the hazard of fighting such a fire.

It now develops that the proper thing to have done was to immediately shut down the entire plant when the defective switch and fire were first discovered. In an Illinois plant with a similar layout of switches, we have had such fires start, but no one had the nerve to fight the flame until power was shut off. The writer would advise all operators to instruct their men to refrain from making any attempt to fight such fires on live switches or other apparatus.

After this first explosion in the switch there were two or three other short-circuits, and half of the bus structure was completely destroyed. All insulating material of a combustible nature was completely consumed, and flames came up from all openings and destroyed other valuable apparatus. By the combined efforts of the entire organization service was resumed again at 5.30 P. M., the accident occurring at 7.30 in the morning. This property was fortunate in having a double set of busses, only half of them being completely destroyed. Had there been only one set the duration of the interruption, no doubt, would have been several days. As a result of this accident, the engineers of the company operating this plant have decided to completely rebuild the switching equipment of this property and all others which are in an unsafe condition. All switches and busbars will be placed out of doors, using weatherproof apparatus completely. This has been done for some years for high-voltage equipment of 13,000 volts and above; so why not for 2,300 and 4,000-volt

systems? The details of this scheme have not been fully worked out, but manufacturing engineers have been consulted and think the proposition feasible. This layout will greatly reduce the possibility of fire and will make a safer proposition for the men to operate and keep in repair.

**All Plant Equipment Subject to Failure at Times.**

As long as we have power plants we will have accidents, and even the best of switching equipment is not perfect and will fail to function at times. We should, therefore, exercise all care to guard against loss of life and property. When a fire once starts in a high-power switching rig, it is extremely unsafe to fight it with the power supply connected. From our recent experience we say: Shut down immediately, then put out the fire, disconnect defective apparatus and resume service. A half hour's interruption is better than taking a hopeless chance.

Frequently switchrooms are partitioned off from all other parts of the power house and are seldom seen by the operators. It would seem advisable that openings be provided, if possible, so that any start of fire could be promptly seen by the station men. These openings should serve a further purpose to allow men to escape in case a fire starts while they are working on the apparatus in these compartments. All switches should be frequently inspected and the oil changed as often as the rupturing capacity of a switch is greatly reduced. Operators should be cautioned about the accurate synchronizing of generators, as this imposes severe service on switches unless done accurately. To improve this accuracy, it is recommended that a synchroscope with a very large dial be used, and that station men take plenty of time to put machines on the lines correctly.

There are plants of considerable capacity where no synchronizing instrument is used, the operators depending entirely on the old lamp scheme, an extremely careless practice.

# Gas Tubing Legislation in Newark.

The fire hazard as well as the asphyxiation hazard of defective flexible gas tubing has long been recognized as serious. The subject has been several times discussed in N. F. P. A. meetings, and the Regulations for the Installation, Maintenance and Use of Piping and Fittings for City Gas, prepared by the N. F. P. A. Committee on Gases and adopted at the 1920 Annual Meeting contain provisions for the control of the rubber tubing hazard. Municipal fire and health inspectors in many localities have power to compel the correction of obviously unsafe conditions. However, according to available information, Newark, N. J., is the only city where the quality of tubing sold is regulated by municipal ordinance.

Public interest in this subject in Newark was aroused in December, 1916, from the death by asphyxiation of two young men. Investigation showed that illuminating gas escaping from a piece of brown paper gas tubing had been the cause of the tragedy. As a result, the municipal ordinance reproduced below in its entirety became effective March 13, 1917.

**An Ordinance Prohibiting the Sale and Use of Other Than Approved Tubular Connections for Illuminating Gas Fixtures and Appliances.**

Be it ordained by the common council of the city of Newark, as follows:

SEC. 1. That it shall be unlawful for any person, persons, firm, or corporation, to use, sell, expose or offer for sale, to install or affix, in the city of Newark, any tubular connection or fabric intended for any illuminating gas fixture, stove, heater or lamp, or other gas appliances, unless such tube connection, hose, or similar device shall have been approved by the inspector of gas and gas meters of the city of Newark.

SEC. 2. It shall be the duty of the Board of Health of the city of Newark, its officers and employees, the superintendent of buildings, the assistant superintendents of buildings, the police officers of the city of Newark, the Bureau of Combustibles and Fire Risks, and the said inspector of gas and gas meters of the city of Newark to enforce the provisions of this ordinance.

SEC. 3. Any person, firm, or corporation which shall be convicted of a violation of this ordinance shall forfeit and pay a penalty of twenty dollars ($20) for each offense.

SEC. 4. All ordinances and parts of ordinances inconsistent with the provision of this ordinance be, and the same are hereby, repealed.

SEC. 5. This ordinance shall take effect immediately.

The following description of the operation of this ordinance is taken from reports and correspondence furnished through the courtesy of Mr. Ellsworth Francisco, inspector of gas and gas tubing at Newark.

As there were no previous standards to follow, immediate regulations based on common sense and prevailing conditions were put into effect with a view to raising the standards gradually until only the best tubing would finally be allowed. At first, a campaign was started by sending copies of the ordinance to all merchants handling tubing and requesting them to submit samples of their tubing to the inspector. It was found that large quantities of tubing that depended on layers of paper to make it gas tight were being sold. This type was unqualifiedly disapproved as well as

NEWARK CITY SEAL
INCORPORATED 1836
INSPECTION OF GAS AND
GAS METERS DEPARTMENT
City Hall, Newark, N. J.
ELLSWORTH FRANCISCO, Inspector
1919
FEB 17 1919
Approved Gas Hose Display Card No. 209
Issued to L. BAMBERGER & CO.
by the Inspector of Gas and Gas Meters of the City of Newark, with his approval of the samples of gas tubing attached to this card.
Ellsworth Francisco. Inspector.
GAS PROOF

*Courtesy Bureau of Standards and Ellsworth Francisco*

**Merchant's Permit Card.**

tubing with a wall of gelatine compound less than 1/32 of an inch thick, common rubber and pure gum hose (the kinds usually used for syphoning purposes), and rubber without an outside coating of gelatine compound. Each merchant was required to obtain a permit card as shown in the illustration and attach each kind of approved tubing which he desired to sell.

The card must be prominently displayed in the store and is good for one year. The merchants were given three months to dispose of their unapproved tubing and at the end of that time a corps of inspectors made the rounds of the city and confiscated any tubing that did not correspond to the samples attached to the merchant's permit cards. The department has issued bulletins from time to time gradually increasing the strictness of the regulations.

Since January 1, 1918, merchants have been prohibited from attaching or selling rubber end pieces separate from the tubing. This rule was found to be necessary because merchants who handled these rubber tips either attached them in a very careless manner or sold them to the customer, who had no knowledge of attaching them. The result in either case was often a serious accident either from fire or asphyxiation. A bulletin was issued requiring the merchant to make the following four simple tests on every length of tubing:

1. STRENGTH TEST.

Take a firm grip on each end of the piece of tubing and pull with a lengthwise strain on the tubing equal to that exerted by lifting a 75 pound weight from the floor. If the tubing breaks apart or the rubber end comes off or the tubing leaks in the last test, reject it.

2. RUBBER END TEST.

Grip both rubber ends in turn between your thumb and fingers and give the rubber end a fairly hard twist. If the ends become loosened or leak in the next test, reject the tubing.

3. LEAK TEST.

Make the final test for leaks in the same manner as that now made by you and reject all tubing that will not stand these tests.

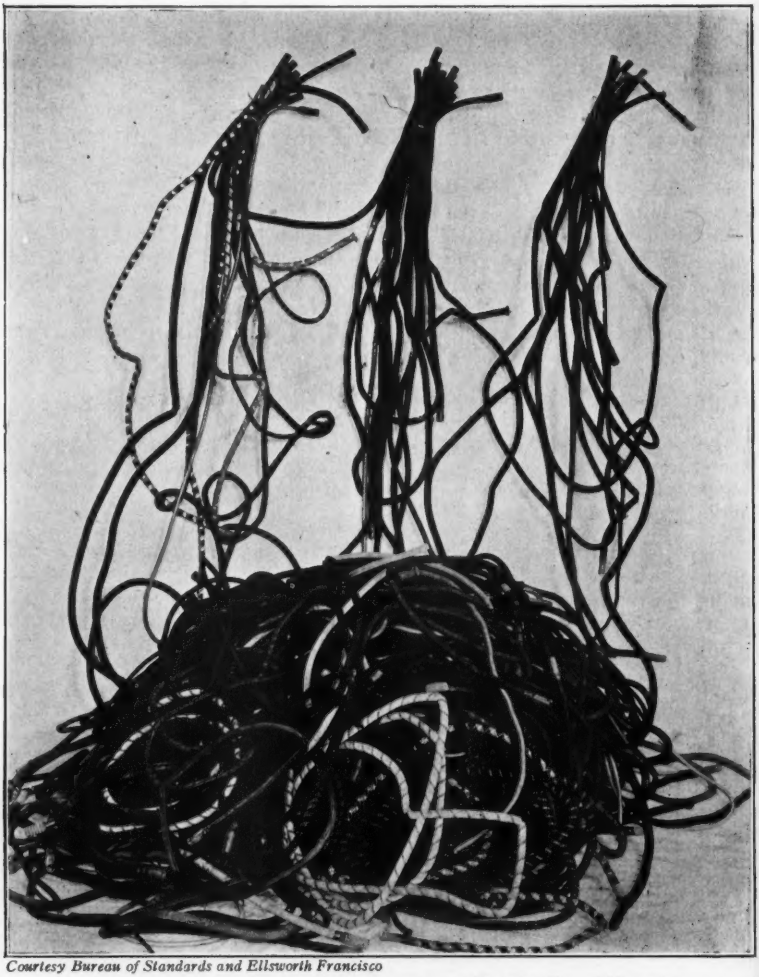
4. Examine the rubber ends and the tubing for other defects than those here specified.

In May, 1920, a bulletin was issued changing the regulations as follows to take effect on September 1, 1920.

"All gas tubing must be strong enough to lift from the floor and hold for fifteen minutes a weight of at least twenty-five pounds without breaking or leaking after the test. Rubber end pieces must be attached in a manner to stand the same test. Tubing must stand, without crushing or shutting off the flow of gas, a weight of 100 pounds per linear inch without leaking and must be sufficiently gas tight when sold so that any length, including the rubber end piece, shall not show any appreciable leakage.

"The quality of the rubber end pieces must be sufficient to stand a test so that a section of one inch square will stretch to at least 3 inches in length. Rubber end pieces must be at least two inches long and have a wall at least 5/32 of an inch thick at the gas appliance end. When attached to a metal hose an approved metal clamp or an approved equivalent must also be tightly fastened to the rubber end piece where it is attached to the tubing. At least 7/8 of an inch of the rubber end piece must be left free for attaching to the gas appliance."

These bulletins as well as the original ordinance are backed up by the city government and violators are subject to arrest and a heavy fine.



*Courtesy Bureau of Standards and Ellsworth Francisco*

**Quantity ot disapproved gas tubing confiscated by the City of Newark.**

It was found that over 90 per cent. of the merchants continued to sell bare metal tubing largely and the inspector plans soon to issue an order prohibiting the sale of bare tubing and requiring principally the use of a metal core with rubber or gelatine compound covering and cloth braid with good quality end attached in a reasonably safe manner. The inspection work has been extended to furnished rooms and boarding houses with a gratifying decrease in loss of life and property from this cause. City statistics show a decline in the number of deaths by asphyxiation each year since the ordinance was put into effect.

**Bureau of Standards Report.**

The Newark gas authorities have received valuable suggestions from the U. S. Bureau of Standards through the tests made by R. S. McBride and W. M. Berry (member N. F. P. A.) and described in a pamphlet, "Tests of Flexible Gas Tubing," Technologic Paper No. 133 of the Bureau of Standards. The reason for the investigation is well told in the introduction as follows: "A large number of accidents in recent years, resulting in loss of life and property, have been caused by the poor quality or the improper and careless use of flexible gas tubing. From the very beginning of its work on the Proposed National Gas Safety Code* the Bureau of Standards has recognized the need for greater care in the selection and use of flexible tubing; but it has also believed that, by proper co-operation of all parties concerned, it should be possible to manufacture such a safe tubing and so to restrict its use to only proper purposes, that the hazards remaining would be practically only those caused by gross carelessness. For the full accomplishment of these objects the Bureau anticipates the need for:

1. A suitable specification for the construction of tubing.
2. A prohibition of the use of poor tubing in any location and a restriction upon the use of even good grades where unnecessary, this to be accomplished by municipal or state regulation or fire insurance rules; and
3. An education campaign addressed to the general public, intended to gain the widest possible acceptance of and compliance with the rules above mentioned, even in places where they are not mandatory."

The pamphlet describes tests made on about three dozen samples of tubing and comments on the tentative specifications of the National Commercial Gas Association and the American Gas Institute as presented at the 1916 meetings of these societies. A set of tentative specifications is also submitted. The conclusions drawn from the tests are briefly that:

1. No one style of tubing may be considered as superior and several of the better forms should be allowed.
2. In general, a non-combustible metal base for the tubing is desirable, but it should not be required for all classes of tubing.

Tubing made up without either metal core or rubber layer reinforced by fabric layers must not be sold.

3. Each length of tubing should bear the label of the maker and the maximum rate of gas flow for which it is suited.
4. Definite specifications as to strength, flexibility, tightness, resistance to heating, and rubber slip-ends should be followed out.

This report is considered as preliminary and it is probable that more work in conjunction with the gas associations will soon be undertaken. The gas associations and companies are doing considerable work in the interests of better tubing since loss of life from inferior tubing naturally creates an unjust prejudice against the use of gas. The Committee on Standardization of Gas Appliance Specifications of the American Gas

*The N. F. P. A. was a member of the conference committee engaged in this work.

Association is now drafting specifications for standardizing a method of testing gas tubing.

**Legislation in Other Cities.**

Gas tubing legislation is at the present time under consideration in the cities of New York and Chicago. A Committee of the New York Board of Aldermen has investigated the situation and approved of an ordinance which has been referred to the Board of Health for adoption. The ordinance omits all mention of the method of manufacture and any tubing which meets with the required tests is permitted to be sold. Coroner Hoffman of Cook County, Illinois, has proposed legislation for Chicago prohibiting the use of rubber hose connections and the subject is being investigated further in that city.

# The Safety Movement and Fire Prevention.

**By Sidney J. Williams, Secretary, National Safety Council.***

**(Member N. F. P. A.)**

Fire causes more than 10 per cent. of all the accidental deaths in the United States. The great majority of these deaths—probably 90 per cent. or more—do not occur in spectacular conflagrations like the Iroquois Theatre and Triangle Waist Company fires; they occur by ones and twos in cities, towns, and villages all over the country, from playing with matches or from careless handling of gasoline or from any of the common causes so well known to firemen. In many of these fires the property loss is insignificant. These fatalities are not preventable by the building of fire escapes or the provision of fire extinguishers; often they are not preventable by anything the fire department can do after the fire has started; they are preventable only by preventing the fire itself. Therefore, it is clear that from the standpoint of saving human life—entirely aside from the tremendous property waste caused by fire—every safety man is vitally interested in fire prevention, and fire prevention is one of the most important parts of the safety movement.

In the past, the efforts of fire departments and insurance organizations have been devoted mostly to the improvement of methods and equipment for putting out fires, and to improvement in the construction of buildings and their contents so they will not burn so readily. Comparatively little attention has been given to the prevention of fire by educating people to be more careful. The feeling seems to have been that one could install a fire wall or a sprinkler system or anything else made of metal or masonry, and could feel fairly sure that it would function properly when the time came—but that the human element could not be controlled. This is the same way that people used to feel about preventing other kinds of accidents; they would guard gears and build railings around dangerous places, but if a man was hurt through carelessness they would say that it was his own fault, and that nothing could be done about it.

* Paper read before the Annual Convention of the National Firemen's Association May 17, 1921.

As a matter of fact, this idea has been found to be totally wrong. For the past dozen years factory after factory and railroad after railroad have found that the human element can be controlled—that men can be educated and trained to be more careful, and that accidents due to lack of carefulness can be prevented just as easily as accidents due to lack of safeguards. By the use of safeguards and education combined, many of our industries both large and small have been able to eliminate from 50 to 90 per cent of their accidents, and thus have saved a great deal of money for themselves as well as saving much loss of life and suffering to their workmen.

We are just beginning to find out that public accidents can be controlled, the same as industrial accidents. For example, the automobile kills over 10,000 men, women, and children per year. Each year, as the number of automobiles has increased, the number of fatal accidents from this cause has increased, both in the country as a whole and in all of the large cities. In fact, the increase has been alarmingly rapid. Yet in St. Louis and other cities the local branches of the National Safety Council have proved that this increase in automobile fatalities can be stopped and turned into a decrease, simply through an organized community effort to teach both the motorist and the pedestrian to be more careful.

The same applies to fire prevention. Great progress has been made on the engineering side of fire protection and fire prevention. Further progress undoubtedly will be made, but it will be slow. The great opportunity lies in prevention through education—education of the workmen in the factory, education of the child in the home, education of men and women everywhere, both at home and at work, including not only the rank and file workman but also the foreman, the superintendent, and the manager, who are often just as careless as their workmen with respect to taking chances of fire.

A fertile field for safety education, including fire prevention, is in the schools. In the public safety campaigns in cities already mentioned, the education of school children has played an important part and has been carried on by an ingenious method, by which safety is not taught as a separate subject but is worked into the regular courses in English, drawing, and other subjects. The children are much interested in this teaching and the result has been threefold. First, the children themselves are more careful in crossing streets and in their play, and the accidents to children have been greatly decreased. Second, the child takes the safety lesson home to his father and mother and this makes them more careful also. Third, the child when grown up is a more careful man or woman and a better citizen. In this safety instruction in the schools, fire prevention has been one of the most important subjects dealt with. The booklet prepared and distributed by the National Board of Fire Underwriters has been of great assistance, both where fire prevention has been taught alone and where it has been included with other safety instruction.

To prevent fires by public education, the following suggestions may be offered:

1. Continue and improve inspections by a fire prevention squad. Assign to this duty men who not only can make a thorough inspection but

who have the ability to show the housewife or the storekeeper why certain conditions are dangerous—adding, where possible, an account of an actual fire caused by similar conditions. The principal purpose and value of these inspections is not simply to detect a dangerous condition but to educate the occupant so that the condition will not occur again.

2. If there is a local safety council or a public safety committee in your town, get into it and co-operate actively. Such an organization is the best possible one to carry on successful fire prevention day observances and similar activities. If there is no such council or committee in existence, try to start one, with the co-operation of the Chamber of Commerce, Rotary Club, Automobile Club, Chief of Police, Superintendent of Schools, street railway company, and others interested. The National Safety Council or the National Fire Protection Association will be glad to give information on how this work has been successfully carried on in other cities.

3. A safety council or public safety committee will help you to get fire prevention instruction into the schools. If you cannot start such a general safety organization try to have fire prevention taught in the schools at least. Use the method worked out by Dr. E. George Payne of St. Louis or as modified in Detroit, Cleveland, Cincinnati, Milwaukee, and other cities.

4. If there are large industries in your town, get in touch with the man in charge of safety work—if the company has no separate fire chief—and make sure that fire prevention is included in the safety instruction which is given to the workmen.

# The Glass Industry.

By Frank S. Welsh.
(Member N. F. P. A.)

## History.

Glassmaking is one of the oldest of arts. Records show that its manufacture was well understood by the ancient Egyptians of the fourth and fifth dynasties (B. C. 4000). Mythology attributes the discovery of glass to the early Phoenecians. From the Egyptians, the Greeks and Romans acquired the art, which in Nero's time was so highly developed that clear crystal glasses were produced in the form of drinking cups and goblets, superseding the use of gold cups. The Venetians and Muranians followed the Romans in the art, and examples of old Venetian glassware show rare skill and ingenuity. To the Venetians belongs the honor of first making glass at a cost to allow its being more generally used, and they also introduced the art into other countries.

Jacob Verelina, a Venetian, introduced glassmaking into England, working at a factory in Crutched Friars, London, between 1550 and 1557, where he made window glass, afterwards carrying on similar work in other places about the country until his death in 1606. In a few years the industry sprang up in the neighborhood of Stourbridge, where were located abundant beds of fire clay, so necessary to glass-makers in building their furnaces and pots, and of coal, used for maintaining the fires for melting their glasses.

In the year 1680 some glass makers were brought to Jamestown, Va., but the craze for tobacco interfered with their industry. About 1700, a glass maker named Jan Smeedes received a grant of land on Manhattan Island and the business he carried on there gave the name of "Glass Makers' Street" to the present South William Street, in New York City. In 1754 a Dutchman named Bamber built a glass works in Brooklyn and the first bottle blown by him, bearing the name and date, is in the collection of the Brooklyn Historical Society. Pittsburg, Pa., first made glass in 1796 and is at present the most important glass making center of this country. In 1827 pressed glass was invented at Sandwich, Mass.

## The Industry in the United States.

There are certain handicaps to the successful operation of the industry on a large scale in many parts of the United States. Chief among them is the shortage of cheap fuel. Glass making requires large quantities of fuel of high heat value. Although soft coal has been largely used in the past, in late years oil and gas have been rapidly surplanting it. Natural gas, especially, has been found both cheap and efficient and the industry has shown a marked tendency to settle in that portion of the United States where this cheap form of fuel exists in a natural state. The following figures, from the latest available Census, show well the concen-

tration of the industry in the Pennsylvania coal and oil regions:

*Number of Establishments Engaged in Glass Manufacture in 1919.*

| | |
|---|---|
| Pennsylvania | 102 |
| West Virginia | 77 |
| Ohio | 43 |
| Indiana | 35 |
| New Jersey | 21 |
| New York | 19 |
| Oklahoma | 16 |
| Illinois | 12 |
| Maryland | 8 |
| California | 7 |
| All Others | 27 |
| | 367 |

The most essential ingredient used in glass manufacture is sand. And this sand must contain a high percentage of quartz. It so happens that Pennsylvania possesses rich deposits of this sort of sand and consequently is able to fortify her hold on this industry.

**Materials of the Glass Industry.**

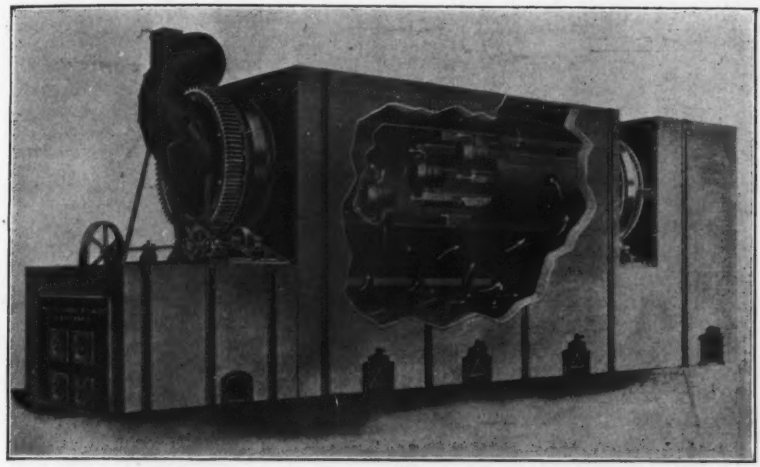
The term "glass," in a general sense, is applied to the hard, brittle, non-crystalline, transparent, opaque, or translucent vitreous substance which results from the fusing of silicic acid with active mineral solvents or fluxes, such as alkalies, earthy bases, or metallic oxides. Silicic acid, or silica, exists in great abundance in a free state in the form of flint, quartz, and sand, and in the latter form is now used most generally for glass making. When sand, alkali, and lead oxide are heated together to a high temperature, the sand is dissolved by the solvent action of the fused alkali and lead oxide until the whole becomes a molten mass of glass. The solvent action of the alkalies, soda potash, or lead oxide is very energetic while being heated, and the mass boils with evolution of gas until the solution settles down to a clear, quiescent, molten liquid "metal," which is quite viscous, after the nature of molasses. In this condition it is ready for working. The time and temperatures necessary for melting such mixtures vary according to the particular proportions and composition of the ingredients.

Following are listed with a brief description, the principal ingredients which go to make up the common grades of glass.

SILICA, combined with various oxides, is freely distributed in nature in clays, granites, and felspars. Originally, glass was made by using crushed and ground flint stones as the source of the silica: hence is derived the old name of "flint" glass. Now, the extensive deposits of white sand and sandstones present a much less expensive and more convenient source and are universally used. Pennsylvania sand, mentioned above, has become famous as the source of much of the glass in America.

The sandstone, as it comes from the quarry, is crushed, ground, screened, and washed to remove the clayey material. After washing the excess water is allowed to drain off and the sand is ready to be dried.

There are several types of dryers in use. Of these, the steam dryer is the most recent invention and is gradually replacing the others, being more economical. These are of brick with horizontal steam pipes inside arranged in tiers and placed closer and closer together near the bottom



**Cummer dryer. Semi-self-contained type, with disc fan.**

of the dryer. The sand is discharged from the top onto these pipes and drops down between the steam coils. Direct fire-heat dryers are of several types, but usually consist of a revolving steel cylinder, set in brickwork, with a coke fire directly below the cylinder. Unless these direct heat dryers are carefully watched the sand is apt to become heated to a temperature sufficient to set fire to any woodwork with which it later comes in contact; disastrous fires have resulted from this cause. After the sand is dried, it is again screened, and is then ready for shipment.

When the sand occurs as a loose, unconsolidated material the process is much simpler, for grinding is then unnecessary and the sand goes directly from the quarries to the washer. Also, sometimes the cheaper grades of sand are not washed at all. None of the above processes are, as a rule, carried on at the glass factory proper, each plant usually buying its supply of prepared sand.

The alkalies, potash or soda, or a mixture of these, are commonly used in making glass in the form of either carbonates, sulphates, or nitrates. The soda and potash silicates form very fusible glasses, but the product is not permanent, being soluble in water; therefore these materials cannot be used alone. In making glassware for domestic use, other materials, such as lead oxide, barium, or lime, have to be added to form more insoluble combinations with the sand.

POTASH is utilized in glass making almost entirely in the form of carbonate, generally called "pearl-ash." It is valued by crystal glassmakers on account of the colorless silicate it forms when fused with best white sand. Potassium carbonate is very hygroscopic and absorbs much moisture from the air; therefore, it is necessary to keep it within sealed boxes.

CARBONATE OF SODA, or soda ash, is used in most of the commoner varieties of glassware. It is available in a state of great purity and con-

stancy of composition, and upon these qualities its great advantages depend.

SULPHATE OF SODA, or salt cake, is used, because of its cheapness, in window and bottle glassware. In mixtures containing sulphate of soda it is necessary to use a small proportion of carbon, in some form, such as charcoal or coal, to assist the decomposition of the salt and the formation of the sodium silicate.

POTASSIUM NITRATE, or saltpetre, is used in glass mixtures to oxidize the molten metal and improve the color of the glass. In fusing, it disengages oxygen gas, which purifies the melting glass, and assists the decolorizers in their action by keeping up an oxidizing condition within the molten glass.

SODIUM NITRATE, or Chili saltpetre, is the corresponding soda salt to potassium nitrate, and is similarly used. It is much cheaper, but less pure.

BORIC ACID acts as an acid in glass, as does silicic acid. It renders the glass more fusible and brilliant. It is an expensive ingredient, but is considerably used in optical and special chemical glassware.

BORAX, or borate of soda, is an active fluxing agent. In moderate proportions it is used in the manufacture of enamel for glass, as it helps to dissolve the colored oxides and diffuses the coloring throughout the enamel mass. TINCAL and BORATE OF LIME are other forms in which borates may be introduced into glass.

CALCIUM CARBONATE, or carbonate of lime, Paris white, limespar, limestone, or whitening, is an earthy base and is added to the simple alkaline silicates and borates to form insoluble combinations or double silicates of soda and lime. By the use of lime, glasses are rendered more permanent and unchangeable when in use. Lime forms a very powerful flux at high temperatures.

DOLOMITE is a magnesium limestone, and is a natural stone which is available for making glass in tank furnaces.

FLUORSPAR, or fluoride of lime, is used to produce opacity. It can only be used sparingly, as it attacks the clay of the pots, due to the evolution of fluorine gas.

PHOSPHATE OF LIME produces opacity but does not seriously attack the pots. "Bone ash" is a form of phosphate of lime.

CARBONATE OF BARIUM, or barytes, is a very heavy white powder and is a form of earthy base available for use in glass making. It can be used instead of lime, and also to increase the density of the glass. Like lime, it is a very powerful flux. It gives increased brilliancy and little coloration, and for this reason it is useful in the manufacture of pressed glassware, giving the glass which leaves the mould a better gloss than is obtainable with the use of lime.

MAGNESIA and STRONTIA are other bases which are occasionally used in glass making.

ZINC OXIDE is a base used in the manufacture of optical glasses. With boric acid it gives silicates of a low coefficient of expansion and special optical values. Used with cryolite, it forms a very dense opal suitable for pressed ware. It is somewhat more expensive than other bases used.

CRYOLITE is a natural opacifying ingredient used in the making of opal glasses. It consists of a combination of the fluorites of alumina and soda and is one of the most active fluxes known to glass and enamel makers. Its cutting chemical action on the clay pots is very intensive. It is imported from Greenland. An artificially manufactured cryolite is a little cheaper and gives similar results.

ALUMINA is sometimes present to a small extent in glassmaker's sands. As such, it is not a dangerous impurity. When used, it has a decided effect on the viscosity and permanency of glass. In large proportions it noticeably diminishes the fusibility of glass and makes it somewhat translucent. Owing to its refractory nature any considerable proportion present in glass causes objectionable cords or striae.

OXIDE OF LEAD, red lead, or minium, is much used in the manufacture of enameled, table glassware, and heavy optical glass. It gives great brilliancy and density to the glass, but if used in excess, the glass is attacked readily by mineral acids and becomes unstable. Red lead is a powerful flux, even at low temperatures, and forms the chief base in making the best crystal ware and enamels.

TIN OXIDE and ANTIMONY OXIDE are used as opacifiers. When used, they generally remain suspended in a finely divided state in the glass.

CULLET is broken scrap glass. In all glasses a proportion of this cullet is used, ordinarily of the same composition as the glass mixture or "batch" into which it is introduced. The use of cullet facilitates the melting, and assists in giving homogeniety to the product.

BASALT and other igneous rocks are sometimes used for bottle glass. These are naturally occurring silicates containing lime, alumina, alkalies, iron, and other elements in varying proportions. They are used on account of their cheapness and produce dark, dirty-colored glasses. Iron, manganese or carbon, may be added to produce black bottle glass.

No single silicate is entirely free from color. Each gives a slight distinctive coloration, the lead silicate being yellowish, and the soda silicate greenish; but by the judicious mixture of different silicates and the use of decolorizers, such as manganese, nickel, etc., compound silicates are formed, giving less perceptible colors or crystal effects. In optical glass-making the use of ordinary decolorizers is not permissible and the purity of the materials used becomes consequently a most important factor.

**Composition of the Principal Kinds of Glass.**

The composition of glasses may be simple, compound, or complex, according to the number of bases or acids which may be present in the mixture.

The SIMPLE TYPES OF GLASS are represented by the soda silicate, potash silicate and lead silicate. Soda silicate is made from the fusion of sand, soda carbonate and charcoal. The fused mass, when cool, is transparent and of a pale bluish color. Upon boiling in water it dissolves and gives a thick, viscous solution, called "water glass," which is extensively used in various arts and manufactures. It has some value in making fabrics and woodwork fire-resistive. Potash silicate and lead silicate are formed in a similar way, the bases being, respectively, potash carbonate and red lead. Lead silicate is mostly used in the manufacture

of soft enamels and artificial gems, and goes under the names of "Rocaili flux," "strass metal," and "diamond paste."

THE COMPOUND GLASSES may be flint or crystal glass, soda-lime glass, Bohemian glass, pressed glass, and sheet glass. These are the general type of glasses used in the manufacture of domestic glasswares.

CRYSTAL GLASS is a silicate of lead and potash, made of best sand, red lead, potash carbonate and cullet, to which a small proportion of potassium nitrate, arsenic, and manganese dioxide is added. The bulk of cut glass tableware and fancy goods is made from this type of glass. It is brilliant and colorless, especially when cut and polished.

BOHEMIAN GLASS is made from sand, potash carbonate, lime carbonate and cullet, with small proportions of potassium nitrate, arsenic and manganese dioxide. This is a hard, brilliant and stable glass, used largely for chemical ware.

PRESSED GLASS is made of sand, sodium carbonate, barium carbonate and cullet, together with small portions of sodium nitrate, arsenic, manganese, and cobalt. It is used by manufacturers of pressed glass tableware or moulded ware.

CROWN GLASS is made of sand, sodium carbonate, lime carbonate, sodium sulphate and cullet, with traces of manganese and cobalt. This glass is used for making sheet window glass.

PLATE GLASS is made of sand, sodium sulphate, limestone and carbon, with traces of nickel oxide, cobalt, or antimony oxide. This is used for cast plate, rolled plate, cathedral, and mirror glass.

THE COMPLEX GLASSES are those in which more than three bases are introduced, and constitute such types as those used for bottles, thermometer tubes, etc. Common bottle glass may be described as an example of a complex formula. It is made up of sand, containing iron and alumina, greenstone or basalt, dolomite limestone, sulphate of soda and carbon. Felspar granites may also be used. Bottle glass requires intense heat to melt, and is usually dark in color when made from igneous rocks owing to the large amounts of colored oxides present in them.

Glass makers' recipes vary considerably in their proportions of the various materials used, according to the locality and type of the furnace used. Generally it will be found that when a gas or oil-fired furnace is used a larger proportion of sand can be used and a cheaper glass produced.

### General Classification of the Trade.

The many and varied articles produced commercially of glass differ widely in their composition and their mode of manufacture. It is possible, however, to group them into certain well defined classes according to their use and the method in which they are made. The following classification of the field of glass making includes all the chief divisions of the industry :

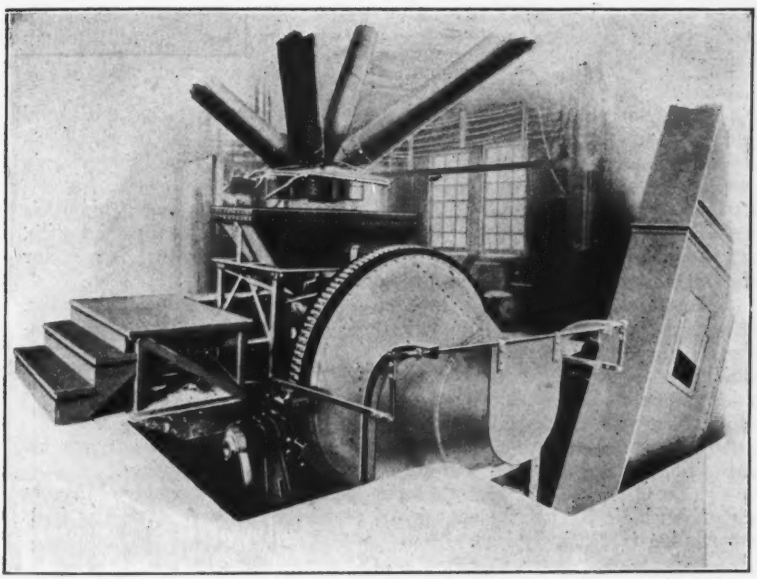
1. Optical Glass.
2. Blown Glass.
   - *a.* Bottle Glass.
   - *b.* Table Glass Ware.
   - *c.* Tube Glass.
   - *d.* Sheet and Crown Glass.

3. Mechanically Pressed Glass.
   *a*. Plate and Rolled Glass.
   *b*. Pressed Table Glass.

The manufacture of each of these particular types of glassware will be discussed later in some detail. There are, however, certain fundamental processes of manufacture which are common to practically all the branches of glass working. A thorough understanding of the processes of the trade should begin with a study of these fundamental operations.

**Preparation of the Batch.**

The necessary mixture of raw materials, which when melted together form glass, is known as the batch. One of the prime essentials of a good glass is that it be well proportioned and thoroughly mixed. The exact



**One ton Smith Batch Mixer, arranged for mechanical handling to and from mixer.**

composition varies considerably, even for the same kind of glass, depending on the character of the raw materials used, the kind of fuel employed, and the style and construction of the furnace. A good batch for one furnace and a certain set of materials often proves unsatisfactory when used for another type of furnace, or when the raw materials are procured from some other source. Recipes for glass batches which are derived from the practices in one section do not always give successful results in some other localities where working conditions are somewhat different.

At the time the batch, consisting of the well mixed raw materials, is put into the furnace, some cullet, or broken glass, is also admitted. Cullet fuses at a much lower temperature than the raw batch and there-

fore assists in the melting. Its presence also holds up and makes the mass more open, thereby allowing the ready escape of the gas during the early stages of the fusion. An excess of cullet, however, produces a brittle or weak glass.

*It is absolutely essential that the batch be thoroughly mixed before* it is put into the furnace. A special room which can be kept clean is usually provided for this purpose. In it are storage bins for the various raw materials and scales for weighing these out. Batch mixers, not unlike the portable concrete mixers used on building construction, are employed in large mills and the materials are conducted to the mixer through the weighers entirely by mechanical processes involving bins and conduits or chutes.

In smaller factories the mixing is done by hand in large wooden boxes or bins. The various ingredients of each batch are turned over a number of times with shovels or hoes and are then usually passed through a sieve of suitable mesh.

### Fuel.

In the early days of the glass industry furnaces were fired with solid fuel, such as coal and wood. Later, however, with the discovery of gas and oil in various parts of the United States, especially in Pennsylvania and West Virginia, these were almost entirely replaced by gas and oil-fired furnaces. This type of fuel has many advantages over solid fuels in the manufacture of glass. There is no ash or dust to contend with, and the burning is easy to control. The furnace temperature is a factor of great importance in glass manufacture.

NATURAL GAS is the best fuel on account of its high calorific value. The great glass manufacturing centers of the United States have, therefore, sprung up where there has been an abundant supply of natural gas available. In recent years, however, with the gradual exhaustion of the older gas fields, there has been a growing tendency to replace natural gas by producer gas or fuel oil.

PRODUCER GAS is manufactured in plants similar to those manufacturing illuminating gas, but without the usual purifying devices.

FUEL OIL has only recently been used for glass furnaces. Present tendencies indicate that the margin of cost between it and gaseous fuels is becoming increasingly less.

### Pots and Furnaces for the Fusion of Glass.

Two types of furnaces are used in the manufacture of glass, namely, pot furnaces and tank furnaces. In the former the glass is fused either in open or closed pots, while in the latter it is fused in large, open hearths.

POT FURNACES are made from special grades of refractory clay. Such clay is comparatively scarce in the United States, being obtainable chiefly in Missouri and Ohio. Before the war large quantities of glass pot clays were imported from Germany and Belgium. These foreign clays are superior to any clay mined in this country.

MELTING POTS used in glass furnaces are of two types, covered and open; the former are used in the manufacture of lead flint glasses and sometimes lime flint, although the tendency is at present to replace open pot furnaces by tank furnaces in the manufacture of lime flint glass. The use of open pots is now confined almost entirely to the plate glass in-

dustry, although at one time they were used also in the manufacture of window and other varieties of glass.

On account of the severe service which is exacted of glass pots their manufacture requires the highest type of mechanical skill. The pots are of various styles and sizes, weighing anywhere from 1,500 to 4,000 pounds. They have not only to sustain their own weight under the high temperature of the glass furnace but must also retain a ton or more of molten glass, the ingredients of which comprise such powerful fluxes as the alkalies, lime, and oxide of lead. In addition, they are subjected to considerable strain, due to unequal contraction when sudden chilling of the interior results from the addition of a new charge.

Three classes of materials enter into the composition of clay pots, namely, unburnt clay, burnt clay, and broken pot shells from old pots returned from service. The burned clay and pot shells are called "grog," and are added to facilitate the safe drying of the finished pots by diminishing the total amount of shrinkage which occurs when the plastic clay is allowed to dry and afterward when it is burned, the burned material having already undergone this shrinking process. The grog also acts as a skeleton which strengthens the whole mass and reduces the tendency to form cracks.

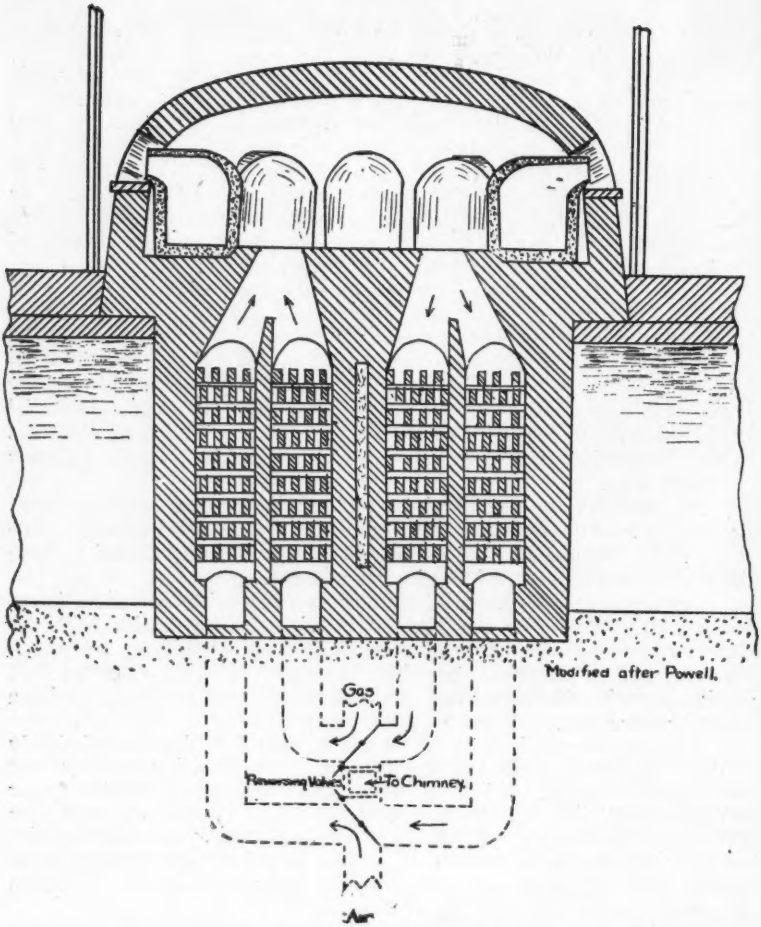
Pot furnaces are usually of the regenerative type, although some of the smaller and older plants still retain the simple fired furnace. The regenerative furnace utilizes the waste heat of the gases escaping from the furnace to preheat the incoming air and gas.

Pot furnaces are generally circular in form with an inside lining, bench and crown of fire clay blocks and brick, and an outside brick enclosure tapering above the crown, forming a stack or chimney not unlike the type used in potteries. The base is usually of brick about ten feet in diameter with a brick arched cave or tunnel. Each furnace contains a dozen or more pots.

When a new pot is to be set in the furnace it is first heated slowly to the temperature of the working furnace in an annealing arch, or "pot arch," as it is called. It is then moved and set into the furnace proper as rapidly and with as little cooling as possible. After the pot has once been set in the furnace it is not allowed to cool again unless the furnace has to be shut down for repairs. A pot has an average life of about three months, although some pots may last as long as ten months. Furnaces are usually run at temperatures of 2552° to 2732° F.

The open pot furnaces used in the manufacture of plate glass are rectangular in shape. They have a width of about three times that of a single pot and are usually made to hold twenty pots, ten on a side.

Tank Furnaces are large tanks, or basins, constructed of burned fire clay blocks. They may be classified in two types, continuous and intermittent. The former are worked continuously and are the type most common in use, while the latter are filled with a batch one afternoon and worked the next day. They are usually rectangular in shape, with interior construction of fire clay blocks and brick with an arched crown, and are supported on brick arches and piers. They vary in size, window glass tanks being as large as 110 feet long by 25 feet wide. The ports for the entry of the gas and air and the exit of the products of combustion are usually placed in the side walls of the furnace, just above the level of




**Section through a regenerative pot furnace.**

the glass. Continuous tanks, as a rule, are divided by means of fire clay obstructions, or floats, as they are called, into several compartments consisting of a melting or charging chamber, a refining chamber, and a working chamber. The batch is charged into the tank at one end and after melting flows under the obstruction to the working end. As fast as the batch is worked out, a new batch is introduced at the other end, so that the melting and working goes on continuously, thus maintaining nearly a constant level of glass in the tank. Continuous tanks are usually operated at a temperature in the neighborhood of 2750° F.

In the case of intermittent tanks, the batch is shoveled into the tank and the work hole closed. Heat is supplied until the glass has reached

the molten stage and freed itself of gas bubbles. Then the heat is reduced, the work holes are opened, and when the temperature has dropped sufficiently, the glass is worked. These tanks as a rule are filled in the afternoon and are ready to work the following morning. For this reason, they are often spoken of as "day tanks." Such tanks are very wasteful of heat and are therefore not used to any extent at the present time.

Relative Merits of Pot and Tank Furnaces. Continuous tank furnaces have a considerable number of advantages over pot furnaces which have led to their adoption wherever they can be made to produce glass of adequate quality for the purpose desired. For this reason, practically all bottle and window glass is now prepared in continuous tank furnaces. On the other hand, when special qualities of glass are required, in relatively small quantities, the pot furnace is still indispensable.

Continuous tank furnaces are the more efficient in the utilization of the heat, give a greater relative output with less labor, are more durable owing to the greater uniformity of temperatures and the costs of pots is less.

Pot furnaces have the advantage over tank furnaces, on the other hand, in that the composition of the glass can be more accurately regulated and the molten glass itself can be more effectually protected from contamination from matter dropping into it, and from coming in contact with the furnace gases. In the manufacture of certain glasses, such as those containing lead, tank furnaces cannot be employed on account of the reducing action of the furnace gases.

### Glory Holes.

Glory holes are small brick enclosed circular furnaces, used for heating the glassware in process of making so as to trim the edges. The older types are fired by an open gas flame located about three feet from the floor, the idea being not to convey much heat downward. The modern furnace is usually fired by fuel oil.

### The Process of Fusion.

The process of fusion is conducted in three stages. First, the raw materials are heated in the furnace to a sufficiently high temperature so that the ingredients melt and react with one another to form glass. Second, the temperature is raised somewhat to cause the glass to become more fluid, thus allowing the gases held by it to pass off more freely. This is called the "fining" process. Finally, the glass is allowed to cool down to a working viscosity.

In the case of the pot furnaces the materials are charged into a pot which has been almost entirely emptied during the previous working out process. During this process the temperature has fallen considerably so that it must be raised before a new charge is added, or the melting will not proceed satisfactorily. During the early stages of the melting large quantities of gas are given off, and this causes considerable foaming. As the raw materials occupy much more space than the finished glass, charging cannot all be done at once, and fresh batches of raw material are added at proper intervals.

In continuous tank furnaces the introduction of the batch into the furnace is a more simple matter, as the temperature is kept as nearly constant as possible. This allows the addition of new materials at almost any

time so regulated that the level of the molten glass in the tank is kept nearly constant. The charge is introduced through a large opening at the "melting" end of the furnace, closed by means of a large fire brick block suspended by a chain and counterweight in front of the opening.

In the case of closed pots the ordinary practice is to work a pot every other day. The time required for melting varies with the size and thickness of the pot, the kind of glass being melted, and the temperature of the furnace. Open pots in the plate glass industry are usually cast once each day. With continuous tanks the operations of charging and working go on simultaneously at the two ends of the furnace.

**Annealing.**

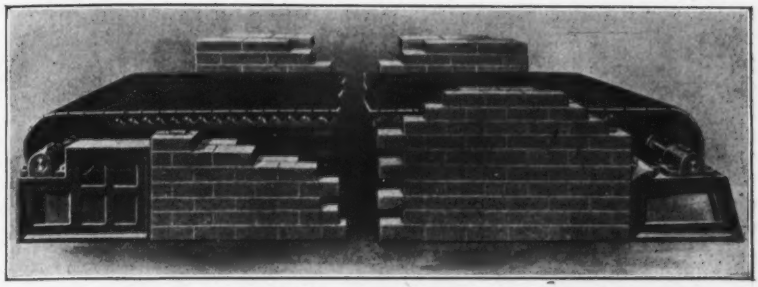
If glass is allowed to cool at ordinary temperatures hardening takes place so rapidly that a tension develops between the outer and inner layers of the glass. This tension makes the glass very tough and strong and gives it the quality of resisting sudden changes of temperature as long as the surface remains unbroken. If, however, this is scratched or cracked, the tension is relieved and the glass flies to pieces. For this reason, all glass intended for ordinary uses has to be "annealed" or cooled slowly, so that the outside and inside layers will cool as nearly simultaneously as possible and all tension be thereby avoided.

There are two types of annealing kilns or ovens in use at the present time; namely, the intermittent kiln and the continuous kiln or lehr.

The intermittent kiln consists of an arch and hearth, usually of brick, on which the ware is laid. It is usually heated by gas, either natural or artificial, but coal or wood may also be used. In the case of hollow ware and flint glass, kilns of this type of firing are so arranged that the heat is evenly distributed over the interior while the glass is laid in. The draught is kept at a minimum at this stage, so that the kiln becomes filled with the products of combustion. When the kiln is filled, it is sealed and the rate of cooling is accurately regulated by adjusting the draught. This type of kiln is still in use in many plants for annealing plate glass although there is a tendency at the present time to introduce continuous kilns or lehrs in this branch of the glass industry. Usually a separate chamber is provided for each plate of glass to be annealed, the process taking from three to five days. Optical glass is usually annealed in intermittent kilns as the annealing must be very carefully done and accurately regulated so that a rate of cooling can be maintained in which a fall in temperature of one degree occupies several hours.

Continuous kilns, or "lehrs," have replaced intermittent kilns to a large extent. They are now employed for annealing much of the hollow ware and flint glass produced, all of the window glass and a considerable amount of the plate glass manufactured. This is due to the fact that the lehr can be operated much more cheaply than the intermittent kiln. The capacity of the factory is considerably increased for the same space occupied and the same outlay for construction and fuel.

A lehr consists of a long brick tunnel heated at the entrance to a temperature just below the softening point of the glass. They are usually fired by gas, but may use coal, coke, or wood. The temperature falls gradually from the point near the entrance where the fire is maintained until at the other end the glass emerges at ordinary room temperature. In the case of lehrs for hollow wares the articles are stacked on trays,



**Endless carrier for lehrs.**

linked together by an endless band, and as each tray is filled it is pushed forward into the lehr, the trays thus following one another down the tunnel at a speed depending upon the rapidity with which each tray is filled. When a tray has been emptied at the cool end it is returned to the charging end. A slightly different arrangement consists in an endless carrier revolving like a belt which can be operated continuously or intermittently at any desired rate of speed. When bottles are being annealed the lehrs used are about seventy feet long and it takes the bottles about three hours to pass through them.

Window glass is annealed continuously in connection with the flattening process. After the sheet of glass has been flattened it is laid at one end of the lehr, which opens into the flattening oven, and is drawn slowly to the other end.

### Processes Used in Working Glass.

As has already been stated, the last stage in the melting operation is the cooling of the glass to the viscosity necessary for working it into the shape of the various articles that are made from it. The procedure followed in manufacturing the different kinds of glass goods varies somewhat for each type. Therefore, a brief outline of the processes employed in the manufacture of the three general classes of glassware, namely (1) optical glass, (2) blown glass, and (3) mechanically pressed glass, is taken up below.

### Optical Glass.

In the production of optical glass, extreme care has to be exercised that only such raw materials are used as possess the greatest possible chemical purity and that these are thoroughly mixed, since optical glass must be absolutely homogeneous. In order to make this mixing more nearly perfect the raw materials are usually employed in a more finely divided state than in the case of the ordinary varieties of glass. Optical glass is made in covered pots. The furnaces differ from the ordinary type in that each furnace holds but one pot, so that the time and temperature of the melting operation can be carefully regulated for each fusion. These pots have thinner walls than those used for flint glass and the fire clay from which they are made has to be more carefully selected so that there will be no contamination of the glass by iron or other impurities from the walls of the pot. The pots are first dried and kilned much as in the case of or-

dinary pots for flint glass. Then, after insertion in the furnace, pieces of the cullet are introduced and melted and the bottom and sides of the pot are glazed to prevent the raw materials attacking the walls of the pot during the early stages of the melting operation. The batch is then introduced, a little at a time, and fused. When thoroughly fused, the glass is ready for the fining operation which must be done very carefully and is accomplished by raising the temperature and maintaining it until the glass is entirely free from bubbles, the process requiring sometimes as much as thirty hours. The scum is then removed and the stirring operation started in order to render the glass perfectly homogeneous and free from striae. It is stirred, manually, with a fire clay cylinder, and from four to twenty hours are required for this operation. By this time the glass has become sufficiently cool and the pot is lifted out of the furnace and placed on a fire brick platform where the glass is allowed to solidify. When it has cooled to a certain point the pot is taken to the annealing furnace where, during the next three days or so, it is allowed to cool down gradually to ordinary temperatures. The fire clay pot is then broken and the glass, which is usually found cracked into many pieces, sorted. These broken lumps of glass are next moulded into the shape of plates by being reheated in moulds. This moulded glass is then placed in the final annealing kiln where it is cooled for ten to twelve days. When cooled the glass is polished on both sides and is then ready to be cut into lenses. The yield from each pot is usually not more than ten or twelve percent of the total glass melted in the pot.

**Bottle Glass.**

Ordinary bottle glass is one of the cheapest grades of glass manufactured, therefore great economy must be exercised both in the selection of the raw materials and in the methods employed in its manufacture. Bottle glasses are as a rule of the lime soda type, but other constituents, such as lime oxide, alumina, are also invariably present. Fortunately color is not an item of great importance and a considerable range in composition is permissible, so that the purity of the raw materials entering into the batch does not have to come up to the high standards set for the better grades of glass.

Practically all bottle glass is now produced in continuous tank furnaces, as these are much more economical to operate than pot furnaces and give very successful results in the manufacture of this type of glass. The raw materials are thrown into the charging end of the furnace and the molten mass of glass flows uninterruptedly down the length of the tank to the colder end where the working holes are located.

Great improvements have been made in recent years in the methods used in manufacturing bottles. The tendency at present is to do a large part of the work, formerly done by men, by machinery and some marvelous mechanical devices have been developed to accomplish this. When bottles are still made by hand the first step is to gather the requisite amount of glass from the furnace. This is done by means of the bottle blower's pipe, which is a hollow iron rod, five to six feet long, provided with a slightly enlarged end or "nose" upon which the glass is gathered. This mass of glass is next distended slightly by the blower, and is then placed in a cast-iron mould whose interior has the external shape of a bottle. By blowing into the pipe the glass is made to assume the shape of the mould. After

this is accomplished the mould is opened and the neck of the bottle is broken from the neck of the rod to which it is attached. The shaping of the neck is done by another workman. It is first heated up to the required viscosity in a small furnace, or "glory hole" and is then moulded into the desired shape by the aid of specially shaped tongs. After this has been done the bottles are ready to be annealed.

Very few bottles are made at present by this process. At present, machines are used in which not only the neck of the bottle is pressed to the desired shape, but the bottle itself is blown in a mould by means of compressed air. In the simplest type of these machines, the glass is still gathered from the furnace by hand. Instead of using a blowpipe for this purpose, however, a light iron rod is used. The necessary amount of glass is gathered from the furnace by the gatherer and placed in a mould, which has the form of the neck with a space underneath, usually in the form of a tapering cylinder, to hold the requisite amount of glass to finish the bottle. As soon as the viscous glass is placed in the mould, a plunger is brought down which presses the upper portion of the glass into the shape of the neck, while the glass underneath takes the shape of the tapering cylinder. The mass of glass is now called the blank. It is removed from the first mould by means of a ring and is placed in another mould which has the form of a finished bottle and is then blown to the shape of the mould by compressed air. When the bottle comes from this mould it is ready to be annealed. Two men are required to operate such a machine, a gatherer and a presser. A further improvement consists in having the glass flow in a thin stream from the furnace into the first mould, the stream being cut off automatically by a knife each time sufficient glass has flowed into the mould, thus doing away with hand gathering. In order to have this process go on continuously duplicate moulds are provided with each machine, so that as one is withdrawn another takes its place. These machines are the semi-automatic type and require only one man to operate them. In addition, one boy is usually employed at each machine to take away the finished bottles.

The greatest invention in the bottle industry in recent years has been a still better type of machine than the ones thus far described, one which operates entirely automatically. This is known as the Owens Automatic Gathering and Blowing Machine, from the name of its inventor. This machine takes the molten glass from the furnace by dipping a preliminary form into the molten glass, mouth down, and exhausting the air so that the glass rises in the form. It then shapes the neck and the bottle itself, and turns out a finished product ready for the annealing ovens, the whole operation requiring practically no attention and going on continuously.

In the annealing of bottles, the continuous kilns or lehrs have entirely replaced the old style of intermittent kilns. Such lehrs are built about 70 feet long and have the first 20 feet heated to a temperature of about 1000° F., which then gradually drops to that of the atmosphere, at the other end of the lehr.

### Table Glassware.

In the manufacture of hollow glass vessels, such as are used for tableware, lamp chimneys, etc., the process of manufacture are very much similar to those used in the production of bottles, the principal difference being in the superior quality of the glass used. There are two types of

glass used in the manufacture of this kind of glassware, namely, lime-alkali-silicate and lead-alkali-silicate. In the better grades of blown glassware it is important that the raw materials be as pure as possible with respect to harmful constituents, such as iron oxide. For the better grades of glass, also, pot furnaces are used because a glass of better color can be made from such a furnace than can be produced in a tank furnace.

Formerly all hollow glass was made by hand. By introducing moulds into which the articles can be blown to the desired shape a part of this hand work has been eliminated. A still later improvement has been the development of machines, very similar to those used in the bottle industry, for blowing the articles into the desired shape by means of compressed air. All of these methods are in use at the present time, although the most primitive, in which hand work is employed entirely, is used only in special cases where but a comparatively small number of the articles of a particular shape are desired, so that it would not pay to make a special mould for them.

In shaping glass articles by hand, the glass blower requires a bench provided with two projecting side rails or arms, across which the blow pipe may be laid in such a position that it can be kept in a gentle rotation by rolling it backward and forward. An ordinary blower's pipe, similar to the one used in making bottles, and a rod to which the glass article upon which the work is being done can be attached by means of a little viscous glass taken from the furnace, are employed, as well as a number of different sized and shaped shears and pincers for cutting off, pressing in, and distending the glass. A flat board and a stone or metal plate upon which the glass can be moulded completes the equipment.

The first step in the production of such an article as a tumbler consists in gathering the proper amount of glass on the pipe and blowing it into a small bulb, which is then blown to the proper size and elongated by a gentle swing of the pipe. Then the lower end of this elongated bulb is flattened by pressing it on the flat plate provided for the purpose. The lower portion of the bulb now has the shape of the finished glass but remains attached to the blowpipe by means of a shoulder and neck. In the hand process the tumbler is next separated from the pipe at the point which leaves it at the correct length. An iron rod is then attached to the bottom by means of a little molten glass and the broken edge of the tumbler is held in a flame (glory hole) to round it. The rim of the glass can then be widened or otherwise shaped by rotating it or pressing it in or out by means of a piece of wood.

Iron moulds are now used almost exclusively in the blowing of such tumblers. These facilitate the operation very much. The glass is gathered on a hollow pipe, blown into a bulb, and after shaping by rolling on a polished plate or by revolving in a hollow iron or wooden block, is blown into the mould and takes its shape. In the case of lamp chimneys, tumblers, and other cylindrical articles, the glass is revolved in the moulds and shows no joint or mould marks.

The final process in the manufacture of a tumbler after it comes from the mould consists in breaking it from the pipe, well above the shoulder, and annealing it. Almost all blown glassware at present is annealed in continuous kilns. Where the glassware is to be cut and polished afterwards, as in the case of many articles made from lead flint,

after it comes from the lehr it is put through a second annealing operation in intermittent kilns of the type already described. This is necessary because it is essential that all internal strain be removed before the glass undergoes the cutting and polishing operation, or it will crack and fly to pieces.

Cut glassware is made from lead flint glass on account of its softness and brilliant lustre. After being given its shape by the processes described above the design is first cut into the glass by pressing it against an iron wheel fed with sand. The rough surface thus produced is then smoothed on similar wheels dressed with a finer abrasive, and is finally polished by a felt-covered wooden bobbin dressed with rouge or putty paste. In the cheaper grades of ornamental glassware, the raised or sunken patterns are produced in the moulds and it is necessary only to go over these designs lightly in cutting and then to polish them to bring out the lustre of the glass.

In etching or embossing hollow ware, hydrofluoric acid is employed. The portions of the glass to remain unacted upon are covered by a "resist" composed usually of a solution of bitumen and beeswax in turpentine, either by first coating the whole article and then scratching off the portions to be etched, or by applying the "resist" with a brush or by a means of a transfer. The article is then immersed in the acid for a short time, then washed and cleaned.

### Tube Glass.

The manufacture of tube glass, a minor part of the industry, needs only brief mention here. Tubes for thermometers, etc., are made largely by hand work in pot furnaces and from specially selected materials. They are produced from a solid molten mass of glass gathered on the end of a blower's pipe. The mass is first made hollow by blowing. Then while one workman holds the blowing iron another affixes an iron rod to the base of the glass. These two men, facing each other and holding the molten mass between them, slowly walk backwards thus drawing out the glass into the form of a hollow tube. The diameter of the tube is regulated simply by the distance carried. In order to have the tube of a uniform diameter throughout it is necessary to regulate its cooling; this is done by men with fans who attempt by fanning the tube to maintain an even temperature along its whole length while it is being drawn.

### Window Glass.

Sheet or ordinary window glass is now prepared almost entirely in continuous tank furnaces of the regenerative type. Until recently all window glass was hand made, but now machines have been developed which are gradually replacing the hand labor. In the old process the blower's pipe is dipped into the glass for the first gathering and allowed to cool until it has become fairly stiff, the whole pipe being meanwhile rotated so as to keep the gathering nicely rounded. A small hollow space is formed in the mass of glass through a slight application of air pressure by blowing. As soon as the first gathering becomes sufficiently viscous a second one is taken. Three, four, or five gatherings are sometimes necessary to obtain sufficient glass on the end of the pipe.

The next step is to blow this mass into a cylinder of equal thickness throughout. The thick lower end of the cylinder is first held in a heating

furnace until the glass becomes of the proper viscosity and then the pipe is swung with a pendulum movement in the blower's pit. The cylinder thus becomes elongated under its own weight and any tendency to collapse is counteracted by the application of air pressure from the mouth. A rotary motion is also given to the pipe from time to time. When the cylinder has reached an equal thickness throughout the rounded end is opened. The lower end is heated until it becomes soft. The cylinder is then held in a vertical position in the pit and spun very rapidly about its longitudinal axis, the glass thus being caused to open out under centrifugal action. It is then allowed to solidify. The complete cylinder is next placed upon a wooden rack and the pipe is severed from the cylinder. After it has cooled the neck and shoulder are removed. The cylinder is then ready to be split, which is done on a special stand upon which it is laid in a horizontal position. The splitting is done by drawing a heavy diamond down the length of the cylinder on the inside. A hot iron, followed by moistening, is sometimes used for the same purpose.

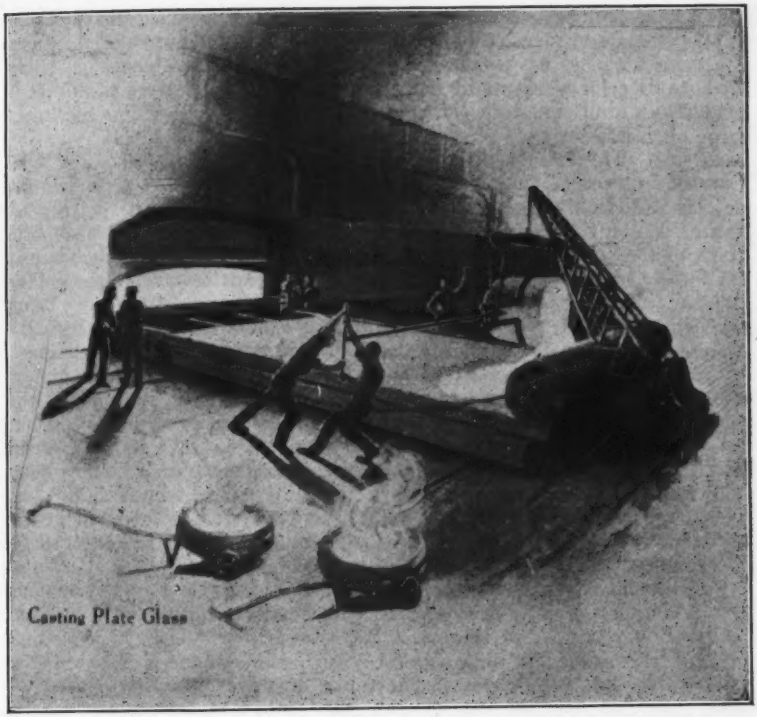
After the cylinder has been split it is ready to be flattened and annealed. For this purpose it is first heated to a dull red color in a special kiln, or flattening oven. The cylinders are then lifted one at a time to a smooth fire clay tile and flattened and polished with a wooden block on a long handle. From there, they go to a continuous annealing lehr.

What the Owen's bottle machine has done for the glass bottle industry, the Lubber's cylinder drawing machine has accomplished for the window glass industry. Machine-made window glass has largely replaced hand-made glass. In using this machine the glass is first ladled from the furnace into a flat, shallow clay pot. The glass cylinders are drawn from these pots. A large blowpipe is emersed into the molten glass, compressed air is introduced, and the blowpipe is gradually withdrawn from the pot. By carefully regulating the speed of the withdrawal and the amount of air introduced, cylinders of uniform diameter and thickness of glass can be made. Cylinders 20 to 24 feet long and 30 inches in diameter can be made with these machines. The splitting, flattening and annealing operations are conducted in a manner similar to that used in the hand process.

When a glass with the lustre of its "fire polish" is needed, as in the case of mounts for microscopic specimens, sheet glass of the type described above is not satisfactory. Crown glass, now almost disappeared from the market, must be used. Crown glass, instead of being blown in a cylinder, is blown in a flattened sphere by centrifugal force in front of a furnace. It is then annealed and cut up into the required sizes.

**Plate and Rolled Glass.**

Ordinarily when the term plate glass is used, polished plate is referred to, but there is another type known as rough-rolled plate, used for skylights, etc., that is also made by being rolled out into a sheet on a metal plate. Rough-rolled plate is a cheap type of glass and is only used where appearance is not considered an important factor. Sand, salt cake, and limestone are the chief raw materials used. Continuous tank furnaces are employed, their construction being very simple, since requirements for regulating the temperature in order to insure perfect "fining" of the glass are not necessary inasmuch as absolute freedom from bubbles is not essential. The molten glass is withdrawn from the tank by means of iron ladles and poured on the rolling table, which is essentially a cast iron slab of the




**Casting plate glass.**

proper size to accommodate the largest sheet to be rolled. A massive iron roller is moved over this slab, driven either by hand or power, usually the latter. When the sheet has been rolled out it is left on the table until it has hardened sufficiently to be safely moved. The sheet is next moved to the annealing lehr, which is of the ordinary type already described. After coming from the lehr the sheets of rolled plate glass are taken to the cutting and sorting rooms, where they are classified and trimmed to the desired shape and size ready for the market.

### Wire Glass.

Wire glass is rolled plate glass in which during the rolling process wire has been imbedded which adds to its strength and prevents it from flying to pieces when cracked, and is thus used in fire-resistive construction. This type of glass is made either by rolling a sheet half the thickness required, placing the wire mesh on this and then rolling another layer of glass on top of it, or by imbedding a mesh of wire in a single thickness of molten glass before rolling it.

### Polished Plate Glass.

Polished plate glass requires much greater care in the selection of

raw materials than does either window glass or rough-rolled plate. Color is an item of considerable importance on account of the greater thickness of the plate glass as compared with window glass, which makes slight changes of color much more pronounced than in the thinner glass. It is made from sand, limestone salt cake and soda ash. The glass is melted in large open pots, twenty of which are usually placed in a furnace, ten on each side. The furnaces are heated to a temperature of about 2800° F. Care is required to insure perfect melting and fining, since even minute defects are readily visible in plate glass, and detract seriously from its value. When the glass in a pot is ready to be cast, the furnace door in front of the pot is raised and the pot is withdrawn from the furnace and carried by means of an overhead crane to the casting table, where it is tilted and the glass poured out in a steady stream upon the table, care being taken to avoid the inclusion of air bubbles during this operation. The casting table consists of a large, massive, flat table of iron, the sides of which are fitted with adjustable strips which permit the production of plates of different thicknesses. As the half fluid glass is poured on the table from the melting pot, the roller quickly passes over it and rolls it out into a sheet of uniform thickness. The red hot plate is then shoved into an annealing oven, which is usually of the continuous type, although many plants still use the intermittent type of kiln because of the difficulties which have been experienced in devising a type of lehr that will insure perfect annealing so that the plates would be able to stand the rough usage of grinding, polishing, etc., to which they are later subjected.

When the plate comes from the annealing oven it has a rough, opaque, almost undulating appearance on the surface, although the inside is perfectly clear. It goes to the cutter, who takes off the rough edges and squares it into the right dimensions. After this is done it is ready for the grinding rooms. The process of grinding and polishing plate glass consists, essentially, of three steps. First, the surface of the glass is ground so as to make it nearly flat, a coarse abrasive being used for this purpose, which leaves the glass with a rough, gray surface. The second step consists in grinding this rough surface by means of finer abrasive until it becomes smooth. The gray surface is still retained. This is removed in the final process of polishing with rouge, by means of which a brilliant, clean surface is produced. After the glass has been polished, it is sorted, classified into several grades, and cut to the desired sizes, ready for shipment.

**Pressed Table Glass.**

Many glass articles, such as saucers and heavy tumblers, are made by pressing alone. The glass is first gathered, in much the same way as blown table glassware, on the end of an iron rod by revolving it rapidly in the molten glass. It is then carried to the presser, who cuts off with a pair of shears the amount of glass required, and allows it to drop into the mould. A metal plunger is then lowered into the mould and the glass is forced to fill the space between the plunger and the mould. When the glass has become firm the plunger is withdrawn, the mould opened, and the article is either sent direct to the annealing lehr or is first reheated in an auxiliary furnace or glory hole to remove the mould marks or to alter its shape. Press moulds are made of cast iron and are constructed in such a manner that the article can be readily removed. The mould and plunger

are kept cool by streams of air blown on them. The plunger is usually operated by hand power, but for some purposes, steam or compressed air are used. Almost all pressed glassware at the present day is annealed in continuous kilns or lehrs. It will be noted that in the case of pressed glassware, no blowing or blow pipe is used.

## Special Hazards of the Glass Industry

Considered as fire risks, glass plants as a class present a number of well defined special hazards. Summarized, these include (1) storage hazards of the raw materials, (2) grinding and dust hazards in preparation of the raw materials, (3) fuel hazards, of natural or producer gas, or fuel oil, (4) hazards in the arrangement of pot and tank furnaces, glory holes, and pot arches, (5) hazards of annealing, (6) hazards of cut glass manufacture, and (7) hazards in the packing and shipping of the finished product.

### Fire Hazards of the Raw Materials.

The storage of most of the raw materials incident to the manufacture of glass involves slight fire hazard. Lime, when occurring in an unslaked state should be skidded and stored in a dry place to prevent its hydration and the consequent generation of heat which this produces. Charcoal, which is frequently used as an auxiliary reducing agent, is subject to spontaneous ignition and should be stored in closed containers in a dry place, skidded off the floor, and away from extreme heat. Sulphur and nitre should be stored separately, as their admixture, together with carbon, might produce a combination capable of explosion with considerable violence. The saltpetre or nitre bags also are likely to ignite spontaneously when piled up after emptying and they should be removed from the building at once and washed or destroyed. The ignition of nitre or saltpetre would serve to aggravate combustion of other material by the liberation of oxygen. It would seem desirable that the hazardous materials described above be stored in a separate building well detached from the main factory group. Manganese dioxide is also occasionally found, and when used should be stored very carefully and away from all moisture because of its ability to break up water and set hydrogen free, thus causing the danger of serious explosions. In addition to the above the sand drying hazard at the grinding mill, referred to in detail in a preceding paragraph, should be noted.

### Fire Hazards in Preparing the Batch.

The preparation of raw stock, such as grinding, screening, and mixing, presents only mild hazards. Grinding and other mechanical devices should be kept from contact with woodwork or other combustible material to obviate the danger of fire from friction. Due attention should also be paid to oiling of the bearings.

### Fuel Hazards.

The fire hazards of natural gas, when used as the method of heating glass furnaces, are similar to those of any other system where the gaseous fuel is generated at a point remote from the place of consumption. All piping to the burners should be well protected against mechanical injury and as much of it as possible should preferably be buried. Shut-off valves should not only be located near the furnaces but also a main valve controlling the entire system at the plant should be installed in some readily

accessible place remote from the furnaces so that, in case of accident rendering access to the valves at the furnace impossible, the gas may be quickly shut off. This valve should preferably be arranged so that it can be closed from outside the building, and it is essential that it be so located as to be protected from frost, falling walls and accumulations of moisture and rubbish.

When producer gas is used the hazard of gas manufacture is added. Where conditions permit, the producer plant should be located in a special building, of non-combustible construction, well detached from the manufacturing group. If space does not allow this and it is necessary to locate the producer in the main building, the generator and all apparatus connected therewith must be placed in a separate room of fire-resistive construction, well ventilated to the outside of the building, and every communication to the main plant must be protected by automatic fire doors of an approved design. The room preferably should be lighted by electricity with all wiring in conduit and lamps in vapor-proof globes; switches should be located outside of the generator room. The generator and all apparatus connected therewith should be installed strictly in accordance with the rules of the National Board of Fire Underwriters. The hazards of a properly constructed producer plant depend mainly upon the installation and the care used in operation. While the explosive power of producer gas is small, about 1 to 16 as compared with naphtha gas, explosions are possible when ventilation is poor and open lamps are allowed.

Fuel oil systems, when properly installed, offer hazards not appreciably greater than those incident to gas installations. The use of fuel oil on any considerable scale is of only recent development. Early installations were experimental and no standards of safety were available; as a result, many fires occurred which are attributable to faulty installation. This situation existed in all branches of industry where fuel oil was utilized. Sufficient field experience, however, has now been accumulated to allow the formulation of regulations providing for the storage and use of fuel oil with comparative safety. If the rules of the National Board of Fire Underwriters in this regard are followed fuel oil installations should be as safe as approved systems of producer gas. In general, gravity flow of oil from tanks to burners should never be permitted. Oil piping should always be arranged to drain back to the tank away from the burners. All piping should be well protected from possibility of mechanical injury. Storage and supply tanks, unless well detached from all buildings and provided with dikes or embankments to prevent the flow of oil toward any building, should be located below ground level and well vented. And, finally, pumps supplying oil to the furnaces should be located in a room, preferably fire-resistive, well cut off from the furnace room.

**Furnace Hazards.**

In the past, the fire danger of housing furnaces using a long-sustained high temperature in buildings of light frame construction has, unfortunately, been largely disregarded. In the arrangement of melting furnaces, both those of the pot and tank type, the chief hazard is the presence of combustible material in close proximity to the furnace. A well built furnace room should be constructed entirely of fire-resistive materials. In the older plants where combustible construction has been employed,

care should be exercised that at least 36 inches of clearance is provided between the walls of the furnace and any combustible floor or roof. In any event, the floor of the furnace room should be entirely non-combustible.

**Annealing Hazards.**

Annealing ovens are frequently found with foundations resting on wooden floors and in too close contact with woodwork and fender boards. It is evident that such ovens should be constructed substantially, with foundations resting directly on the ground, and should be kept free from contact with combustibles, including such material as is frequently found piled on top of the arches of both lehrs and ovens. Preferably they should be located, like glass furnaces, in buildings of fire-resistive construction.

**Hazards of Cut Glass Manufacture.**

The hazards incident to the cutting and etching of glassware are relatively small. Acids, used in etching, usually sulphuric and hydrofluoric, should always be kept in a small building, detached from the main group and away from organic material. Care should be taken in the arrangement of melting devices for wax and glue. Tables used for applying and drying the silver nitrate solution which is used for making silvered glass are usually steam-heated and when so present little hazard.

**Packing and Shipping Hazards.**

Glass plants require a considerable quantity of packing material to insure the safe shipment of their wares. Several carloads of highly combustible material is likely to be scattered about in the packing department of the plant. Sometimes only salt hay is used which is not as hazardous as excelsior, straw, or hay. Packing bins are out of the question owing to the quantity used, but the packing room should be lined with sheets of lock-jointed tin (similar to a fire-door covering) with an automatic fire-door of the same construction at the opening. The packing room, moreover, should never be located in close proximity to the furnace room; preferably, it should be in a building detached from the manufacturing group, but if congestion prevents this it should be cut off from the manufacturing section by a standard fire wall. The packing room should invariably be equipped with automatic sprinklers.

Smoking is usually prevalent in glass factories. In the furnace rooms it seems hard to prevent; glass makers, as a class, being tempermental and of an artistic nature, are inclined to resent any attempt to curtail their personal liberties. In other portions of the plant smoking is of more vital importance than in the furnace room where little combustible material is present. In the packing departments, especially, smoking is of course absolutely suicidal and should here at least be strictly forbidden.

## Fire Record in Glass Plants

Study of the fire records of the N. F. P. A. discloses some very interesting information regarding the causes of fires in glass factories. In all, a total of 237 fires have been recorded which are classified in the accompanying table.

Among the fires classified as from common hazards, those caused by matches and smoking are of special interest in view of what has just been said above regarding the prevalence of smoking and serve as telling proof

**Glass Plant Fire Record.**

| Cause of Fire | Number | | Per Cent. | |
|---|---|---|---|---|
| **COMMON HAZARDS** | | | | |
| Heat | 13 | | 5.4 | |
| Light | 15 | | 6.3 | |
| Power | 11 | | 4.7 | |
| Smoking and matches | 13 | | 5.4 | |
| Miscellaneous common hazards | 1 | | 0.5 | |
| Total | | 53 | | 22.3 |
| **SPECIAL HAZARDS** | | | | |
| Melting tanks and furnaces | 35 | | 14.8 | |
| Annealing ovens and lehrs | 11 | | 4.7 | |
| Fuel oil system | 25 | | 10.6 | |
| Gas producers | 6 | | 2.6 | |
| Spontaneous ignition | 16 | | 6.7 | |
| Miscellaneous special hazards | 16 | | 6.7 | |
| Total | | 109 | | 46.1 |
| **MISCELLANEOUS HAZARDS** | | | | |
| Exposure | 9 | | 3.3 | |
| Lightning | 2 | | 1.0 | |
| Incendiary | 5 | | 2.1 | |
| Tornado | 1 | | 0.5 | |
| Unknown | 58 | | 24.1 | |
| Total | | 75 | | 31.6 |
| | | 237 | | 100.0 |

that smoking should be positively forbidden. The other fires under thi classification are ordinary and uninteresting for purposes of this dis cussion.

Under the classification of special hazards, melting furnaces caused total of 35 fires. Of this total, 20 were caused by the tank breaking an allowing molten glass to flow out on combustibles located nearby. I addition, five more were caused by hot glass overflowing and ignitin woodwork, and two by heat from the furnace walls setting fire to wood work located in too close proximity to the furnace. These cases emphasiz the vital importance of constructing the furnace room entire of non-com bustible materials, and of prohibiting absolutely the use of wood floorin and roofing. Moreover, of the eleven fires attributable to annealing oven and kilns, at least eight were caused by overheating of woodwork. I seems that too much importance cannot be placed on the need of safe guarding this hazard.

Of the fires caused by the several types of fuel employed the promi nence of fuel oil systems is at once noticeable, and a comparison wit producer gas fires on first sight speaks very unfavorably for fuel oil. A has been said above, fuel oil installations are a comparatively new de velopment in the glass industry. It is plainly evident that, as originall installed, fuel oil presents a considerable hazard. This hazard has bee recognized, however, and recent rules have been adopted with a view o making such installations as safe as any other form of fuel. It is of in terest to note in this connection that of the 25 fires caused by fuel o installations, 23 were due to broken or leaky supply pipes. Hence, i determining the hazard of a glass factory it is of prime importance i determining whether the fuel oil installation is standard or substandard If the latter is the case, consequent caution is advisable.

The miscellaneous special hazard fires contain no predominating features, except that three can be attributed definitely to fires in packing material. Three are due to glory holes and pot arches coming in too close contact with woodwork. These only serve to add to what has already been said on this subject. Two fires were caused by hot moulds used in shaping glassware. One was caused by the boiling over of a kettle used in melting wax for etching. In addition to the smoking fires mentioned above, it is probable that some of the sixteen fires attributed to spontaneous ignition in reality belong in the former class.

Of the miscellaneous hazards, it is interesting to note that all of the exposure fires, nine in number, were caused by sparks from passing locomotives.

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### Glass Industry in the United States.

Note.—The following table has been made available by the Bureau of the Census since the above article was written and is included as it shows the growth of the industry in recent years.

| | No. of Establishments | | Production | |
|---|---|---|---|---|
| | 1919 | 1914 | 1919 | 1914 |
| Building Glass* ..... | 125 | 102 | $ 83,718,000 | $ 36,824,000 |
| Pressed and Blown Glass .... | 130 | 107 | 70,708,000 | 30,279,000 |
| Bottles, Jars, etc. ..... | 139 | 150 | 87,762,000 | 51,959,000 |
| All Other Products ..... | | | 12,521,000 | 4,023,000 |
| Total for the Industry ... | 367 | 348 | $254,709,000 | $123,085,000 |

* Building glass includes window glass, obscured glass, including cathedral and skylight, plate glass, and wire glass.

# Transformer-Vault Construction.

By H. J. Clark.*
*Engineer, Oklahoma Inspection Bureau.*
(Member N. F. P. A.)

Oil-cooled transformers have always been considered a distinct fire hazard, and recommendations in general have asked for the elimination of these devices from the inside of buildings. In the great majority of installations, because of the relatively small amount of power required, the distribution of electrical service by overhead transmission lines, and the moderate voltage used, it has generally been practicable to install the transformers on poles or platforms on the outside of buildings.

With the development of the large electric power plant, followed by cheaper rates, there has been a great demand for electric power by manufacturers, particularly in the larger cities. Often very large quantities of power are used by single consumers, necessitating the installation of electrical equipment approaching in size that of fair-sized substations. In congested districts distribution is now largely underground, and operating companies have found it practicable to distribute current at very high potential, 6600 and 13,200 volts being not uncommon. Equipment, including the necessary transformers in connection with such services, requires considerable space.

**Separate Building Best for Transformer Vaults Where Possible.**

Where space permits it is desirable and strongly recommended that a separate building of fire-resistive construction be provided, and in such cases, as there would be no exposure to other property of high value, the structural features of the building such as thickness of walls and roof are of little importance. The size of such buildings must necessarily depend on the bulk of the equipment to be used and the space necessary for insulation, ventilation, accessibility, and in every instance sufficient space for safety to attendants who may enter the building.

In congested districts, where space is not available for detached buildings to house transformers and station equipment, it becomes necessary to house the equipment in buildings used mainly for other purposes. The inspection department having jurisdiction should always be consulted before definite installation arrangements are made, mainly for the reason that the installation will often result in changes which will affect the fire hazard. Although every insurance bureau and practically all municipal departments have established rules governing installation, the bureau engineer can often make suggestions regarding the location and arrangement of the transformer vault or room which will provide added safety;

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* Paper read before meeting of Western Association of Electrical Inspectors. Reprinted by courtesy of the *Electrical Review.*

and we cannot go too far in this respect where very large values are involved.

The vault should preferably be located in a portion or division of the plant easily accessible to firemen and, so far as possible, with non-combustible surroundings. If the vault is in a building of fire-resistive construction the top of the vault may be formed by the floor above, if such floor is fireproof. If the floor or roof above is of combustible material the vault ceiling should preferably be 3 feet below the floor or joists, and the space left open and accessible.

**Present Code Rules More Liberal Than Those of the Past.**

The rules regarding transformer installations, as contained in the 1920 edition of the National Electric Code, are more liberal than in previous editions, so that it is not now impracticable to strictly comply with them. The code now permits wires of circuits with potential up to 5000 volts to be brought into buildings, and extra-high potentials—above 5000 volts—may be brought into transformer vaults. The rules governing installation of transformers seem adequate to safeguard the fire hazard of these devices, but it might not be amiss to discuss the provisions as contained in Rule 45.

In Section (a) it is stated that "Transformers must not be placed inside of buildings other than power stations and substations without special permission. They must be located as near as possible to the point at which the primary wires (referring to potential less than 5000 volts) enter the building, and must be placed in an inclosure of fire-resisting material, with an air space of at least 6 inches on every side." The above is interpreted to refer only to the air-cooled type of transformer. Natural-draft air-cooled transformers are limited in size by common practice and economy to capacities of 5 kw. or smaller, with a voltage of 600 or under. The burning out of a transformer of this size and type would not result in a large flame or great amount of heat, and would be sufficiently safeguarded by a tight inclosure equal in fire-resistive qualities to 0.25-in. asbestos board, 22 gage sheet iron, or metal lath and plaster, with incombustible supports. Air-blast transformers are built in larger sizes and for higher voltages, but seldom exceed a capacity of 200 kw. These transformers are generally installed in units of three single-phase or one 3-phase transformer ventilated by a single blower. The larger units have sufficient inflammable material in their construction to generate considerable heat in case of burn out, and, should the blower be shut down, the fire may communicate to other units if more than one are installed. Adequate protection for the larger installations would be secured by an inclosure equal in fire-resisting qualities to 4-in. tile or gypsum blocks. Section (a) further states: "The inclosure must be securely locked, and access allowed only to authorized persons. It must be thoroughly ventilated, preferably through a chimney or flue to the outside air.

The size of ventilator will depend on the size of the apparatus and the draft conditions. The ambient temperature must be kept below 40 deg. C. Adequate ventilation for inclosures containing natural-draft air-cooled transformers could probably best be secured by placing one or more screened openings in the wall of the inclosure near the floor, not larger than 6 by 12 ins., and placing a ventilator near the top having a size not

less than 12 ins. square if opening directly to outside air, but possibly smaller if connected with a flue or chimney having good draft. (b) The transformer case must be permanently and effectively grounded in accordance with rule 15A. (c) Oil-immersed transformers in buildings other than power stations or substations must be inclosed in fireproof vaults constructed as follows:

"(1) The inclosure must consist of concrete not less than 6 ins. in thickness, or of brick not less than 8 ins., except that when the total transformer capacity so inclosed is not over 100 kilo-volt amperes the above thickness may be reduced to 4 ins., provided approved fireproof material is employed and the construction of the vault is specifically approved by the inspection department having jurisdiction. Outside walls of the building, if of fireproof construction, should preferably constitute one or more of the walls of the vault or inclosure.

"(2) Transformer vaults or inclosures must be provided with means for ventilation which will prevent the development of room temperatures in excess of those at which the transformers installed therein may be safely operated. Limiting temperatures shall be determined in accordance with and in the manner described by, the standardization rules of the American Institute of Electrical Engineers, and temperatures under full-load must not exceed the values given in those rules. All ventilating openings not connected to chimneys or flues shall be provided with automatic or manually controlled dampers to prevent the emission of smoke or fire. Damper controls should preferably be arranged to be operated from a point outside of the vault."

At this point it may be noted that the measurement of transformer temperature, as prescribed by the A. I. E. E., is by the resistance method. These rules establish, in general, temperature limits as follows for oil-cooled transformers using fibrous insulations at rated load:

| | Deg. C. |
|---|---|
| Permissible hottest spot temperature | 105 |
| Hottest spot correction | 10 |
| Limiting observable temperature | 95 |
| Ambient temperature | 40 |
| Limiting observable temperature rise | 55 |

The temperature rise of a transformer is dependent on losses in the core and windings and many other design features. There are now devices for measuring the hot-spot temperatures, and operating companies can obtain and furnish to consumers transformers of known temperature rating which will meet with this rule. Transformers that will conform to the above requirements will have a temperature of about 40 deg. C. at 75% load, and 30 deg. C. at 50% load. The ventilation then must be sufficient to maintain ambient temperatures not in excess of 40 deg. C. or 104 deg. F. It is impracticable to estimate the size of the ventilating openings necessary to maintain the required temperatures, but it is believed, however, that for equipments of not over 50-kw. capacity two vents connected with the outside air, one near the floor and the other near the ceiling, each having an area of 144 sq. ins., would be ample. For equipment up to 100 kw. 2 sq. ft. to each vent should provide adequate ventilation. The conditions and location of the vault should govern ventilating requirements for the larger sizes. In large units, such as are often used in indoor installations, the oil-insulated transformers are

frequently water cooled. The cases of such transformers are cooled, the heat being carried out by the cooling water, hence the ventilating area required would be much less than for types depending on heat radiation from the transformer cases.

"(3) Where practicable, a suitable drain must be provided which will carry off any accumulation of oil or water that may collect in the vault. Floors and drains should have a pitch of not less than 0.25 in. per ft. In vaults containing transformers having a total capacity of 100 kv-a., or less, the drain may be omitted if the inclosure is so constructed as to retain all of the oil within the vault.

"(4) Unless opening is from the outside of the building only, the doorway to the vault must be thoroughly closed by means of an approved tight-fitting fire door. A door sill not less than 4 ins. in height must be provided. In all cases the sill must be of sufficient height to confine within the vault the oil from the largest transformer installed. (d) It is recommended that when oil switches are used to control transformers, such switches be located within the vault or inclosure."

A few words might be said in regard to fire extinguishment in transformer vaults or inclosures. Of course, the first act would be to cut off the power supply from the apparatus. Some favor pole cutouts on the outside of the building, and when these are installed the disconnect should be made at this point. Where the service is connected to an underground distribution system the disconnect must necessarily be inside of the vault, but it should not be necessary for the attendant or fireman to enter the vault for this purpose. It seems to be good practice, and not in violation of the rules of the code, to install electrical or manual-control devices on the outside of the inclosure. After disconnection, fires within the vault should be easily controlled and extinguished by carbon tetrachloride types of extinguishers. Where automatic sprinklers are installed in a building the protection should not be extended into electrical-apparatus rooms containing high potential, except a valve be installed in the line controlling sprinklers in the vault and the valve be kept closed except in case of fire, when water must not be turned on until the power is cut off. Instructions should be posted on a card attached to the valve.

# Transformer Fire Record.

The Fire Record of Electric Light and Power Houses discloses twenty-two fires occurring in the transformer house, all of the fires being in the special hazard class. Of these only eight were due directly to the transformer. Eight were caused by lightning. The remaining six were from miscellaneous causes as follows: Two from a short circuit at the switchboard in the transformer house, one from spontaneous ignition of waste, one from an arc in the line switch made by a man disconnecting switch with a metal pole, one from a spark from a rotary converter entering blower and passing under transformers, and one from a short circuit of unknown origin.

Three of the eight transformer fires are described in the Fire Record of Electric Light & Power Stations in the October, 1911, QUARTERLY. A description of the other five follows:

**H-12751.** Shortly after nine o'clock in the evening practically simultaneous short circuits occurred in four underground cables and at a bank of three large air-blast type auto-transformers in the transformer house. The short circuit at the transformers, which was of unusual severity, involved all of the connecting cables, cable supports and grounded metal work in the air vault under the transformers and the lower ends of the coils of the transformers themselves. From the condition of the vault after the accident, it would appear that the whole vault had been transformed into a huge electric furnace supplied with power from the three 15,000 K. V. A. turbo-generators which were running on the system involved. The arcing and the fire which followed completely destroyed the transformers and damaged the vault and the floor above it.

The generators at this plant are divided into two groups, each group supplying a separate system. The 13,800 volt system is supplied with power by three 15,000 K. V. A., 6,900 volt turbo-generators, the power being stepped up to 13,800 volts by air-blast auto-transformers connected into the leads of each generator. Two of the generators each have three single-phase auto-transformers rated at 5,000 K. V. A. output each and the third generator has a three-phase auto-transformer.

The transformers are located in the transformer house above the vaults through which the air blast is supplied, a separate vault being provided for the transformers of each generator. The same blowers, however, supply air for the six single-phase transformers of generators Nos. 6 and 7. The air after passing up through the transformers is discharged into the main transformer room through dampers at the tops of the transformer cases, which are used to regulate the air blast. Air is also discharged through one side of each case perforated for the purpose.

Each generator is controlled by a non-automatic oil switch of the remote control type, which is connected into the generator leads between the transformers and the bus. There is also in addition to the usual measuring instruments a reverse energy relay connected into the leads of each generator between the transformers and the bus. The object of this instrument is to indicate by the lighting of a lamp when the generator takes energy from the bus instead of delivering energy to the bus. Portions of the exposed cables in the vault were thoroughly wrapped with asbestos tape to form a fireproof covering tending to prevent the spread of fire along the cables.

The outgoing cables from the 13,800 volt bus supply power to suburban transformer sub-stations, and each of these cables is protected by an oil circuit breaker. These cables are of the three conductor lead sheathed type in separate underground ducts, and the cables on which the trouble occurred were of No. 0000 B. & S. gauge. These underground ducts pass out of the station through the south wall of the switch house, and are run under the present frequency changer room. It was at this latter point, barely 200 ft. from the point where the cables are connected to the bus, that the cables short-circuited.

When the accident occurred the station operators distinguished three short circuits following one after another, the third one continuing for possibly two minutes, which under the conditions was a long time. It was found that the oil circuit breakers on four of the outgoing feeders had

opened automatically and that current was flowing from the bus to the leads of No. 6 generator, indicating a possible short circuit in No. 6 generator, in its transformers or in its leads at some point between the generator and the reverse energy relay, as the latter was located between the transformer and the bus. Such a short circuit would be supplied with power from two directions, first, from the No. 6 generator at 6900 volts, or at 13,800 volts, depending upon the location of the short circuit, and second, from the other two generators at 13,800 volts through the bus and the No. 6 oil switch. The switchboard operator immediately opened the oil switch which connects the No. 6 generator with the bus, thus cutting off the current being supplied by the other two generators, and after about two minutes, according to his estimate, he opened the field switch of the No. 6 generator, stopping the arcing. By this time dense volumes of smoke were pouring from all three transformers of the No. 6 generator. The insulation of the transformers had become thoroughly ignited and continued to burn fiercely, fanned by the air blast. As soon as possible the load was taken off from the No. 7 generator, so that the fan which was supplying air to both sets of transformers could be shut down. This was not done, however, until about fifteen minutes after the short circuit occurred.

Efforts were then made to extinguish the fire. Twenty to thirty carbon tetrachloride fire extinguishers were used without effect other than to drive the men out of the room repeatedly for fresh air. Large amounts of sand were used with noticeable effect, the sand being applied through the dampers at the tops of the transformer cases. Two three gallon chemical extinguishers were also used to extinguish the fire in the connections at the bottoms of the transformers, the streams being applied through openings in the bases. The dampers at the tops of the transformers were closed during the most of the fire except when the sand was being applied, but this did not greatly retard the fire. The tops and upper parts of the casings were red hot and flames issuing from the transformers reached nearly to the roof. The heat and smoke from the fire and the fumes from the carbon tetrachloride made it difficult for the operators to stay in the room and it was impossible to get near the air vault. Efforts to extinguish the fire were finally abandoned since it was felt that the fire did not hazard either the building or the adjacent transformers. The fire continued to burn with less and less intensity until some time two days later. At no time during the fire was water from hose streams used, due to the liability of damaging the other high voltage apparatus in the immediate vicinity of the burning transformers and possibly causing serious interruption of the service.

Inspection of the vault and transformers later showed that, owing to the great amount of electrical energy expended, the heat was extremely intense. Arcing evidently took place between all live conductors in the vault and between these conductors and all grounded metal work at many points simultaneously. All of the large connecting cables were vaporized or melted, the arc burning back along the cables and vaporizing them in the underground ducts for twelve to eighteen inches below the floor level. The angle iron cable supports, which were 2″ by 2″ and 3″ by 2″ were melted in two and a length of at least 2 feet of the largest one was melted

or vaporized. The flange of one of the I-beams supporting the floor was melted at one point and one of the beams was so softened and weakened that it allowed the concrete floor above to sag noticeably. Whole sections of the iron conduit carrying the lighting wires were melted or vaporized. Four tin-clad fire doors at openings between this vault and passageways were destroyed, the wood being reduced to ashes and the metal coverings and fittings being melted in places by the electric arc. The transformer cases also show evidence of arcing at several points and some of the coils of each transformer have been melted through at the lower end by the arc.

The surface of the brick walls over considerable areas was slagged by the intense heat of the arcing, an analysis of pieces of this slag showing it to contain a large percentage of copper. This would indicate that vaporized copper carried by the arcs playing against the walls had, under the extreme heat, united with the silica of the bricks, forming copper silicate.

Just what started the arcing is not known, but it was probably due to either surge of voltage following the short circuit in the underground cables or the melting out of a connection or injury to the cable insulation by distortion of a cable or cables by magnetic forces caused by the rush of current. Also it is not known where the arc started, but, regardless of where the arcing first took place, it is evident that it flashed instantly throughout the vault and the transformer bases, melting the metal work and igniting the insulation on the cables and transformer coils.

**H-15019.** This fire was first discovered by the appearance of volumes of smoke coming from the transformer room after an interruption of the main circuits; compelling a shut down of the entire plant, at 8:30 A. M. while the plant was in operation. It is believed that there was a defect in the transformer and that when it broke down the high tension voltage jumped across to the secondary circuit, causing a break down in the generator on this circuit and setting fire to the secondary cables in the basement as well as to the transformer itself. The transformer room is of fire resistive construction and is divided into three sections separated by 6″ concrete walls. Openings are protected by roller steel doors. At the time of the fire the door between the south sections was open and the other closed. One opening between the transformer room and rotary converter room is protected by a non-automatic tin clad door, on track screwed in wall. This door is kept closed. One of the transformers in the south section boiled over and undoubtedly a great amount of oil flowed through the floor to the cable room beneath, intensifying the fire in that room. The gases formed exploded and blew out the roller steel door between the two north sections. At the start of the fire a valve controlling steam jets in the transformer room was turned on and the room flooded with steam. This reduced the intensity of the fire, permitting the later use of chemical extinguishers. It was impossible to reach the seat of the fire before 10:30 A. M. when the fire was extinguished by the use of 70 gallons of carbon tetrachloride and 31 chemical extinguishers of the 2½ gallon type. After the fire an examination showed that the greatest heat was generated in the cable room under the transformer room. This room is about eight feet high and extends under the two south sections of the transformer room. The ceiling is the reinforced concrete on exposed

steel I-beam floor of the transformer room. The floor is of heavy wood planks on exposed steel I-beams, with open space under. This room does not communicate with the transformer room except through small orifices through which the cables pass. It communicates, however, with the basement of the rotary converter room; the opening being protected by a sliding wooden door. The steam jet does not enter this room perhaps accounting somewhat for its failure to be more effective.

The insulation of the cables which are on the secondary circuit was entirely consumed and the door protecting the opening to the rotary converter room was badly charred. Some of the heavy floor planks were charred and consumed, dropping into the water underneath. The ceiling was practically unharmed. In the north section aside from the one transformer and the insulation on the cables there was no damage of note. The plant was able to resume operation again at noon.

**H-15772.** The transformer house was an electric sub-station containing two 75 K.W. 3-phase oil-cooled transformers. It was of wood joist construction. Employees of the company had been in and out of the building frequently during the day while making repairs on the line nearby which necessitated operating switches inside the building.

At 6:30 P. M., shortly after they had left for the night, a short circuit caused an arc in one of the transformers and almost at once the house burst into flames. No fire protection was available and the building burned to the ground. Dwelling houses exposed by the fire were protected from the fiercely burning oil by a volunteer bucket line and these houses were saved.

**H-8962.** This transformer house was of brick with a metal roof and plank floor. Fire broke out at 8 A. M. at the time that the full load usually comes on. The intense oil fire lasted for a short time and badly buckled the corrugated sheet iron roof. It was extinguished by two hose streams from the city fire department.

The days just previous to the day of the fire were very warm and as the transformers are run fully loaded during the day, they probably did not radiate the heat as fast as it was generated and gradually reached the temperature at which the wood bases ignited. Damage was confined to transformer house.

**H-1103.** This transformer station was located in a small one and two story building with joisted floors, plaster ceilings and open wells. The station steps up the voltage for transmission to transformer stations in a suburb where the voltage is stepped down. The cables ran underground and a short circuit occurred where the wires leave the underground conduits and ascend a pole. The current came back to the transformer station and burned out the transformers, setting fire to the building. The fire was extinguished by the city fire department after considerable damage to the contents of the building.

Probably the most interesting of the other transformer house fires is one occurring at a cotton mill in New Hampshire.

**H-15883.** A set of five air-cooled transformers was in a frame station in the yard of the mill. The transformers were cooled by a blower

which takes air from the inside of the mill. The air is blown through a wooden duct underneath the transformers. There was considerable lint from the cotton mill in the duct and it is believed that a spark from a rotary converter entered the duct and ignited the lint. All five of the transformers were burned out. The fire was extinguished by hand chemicals and a small hose after considerable loss.

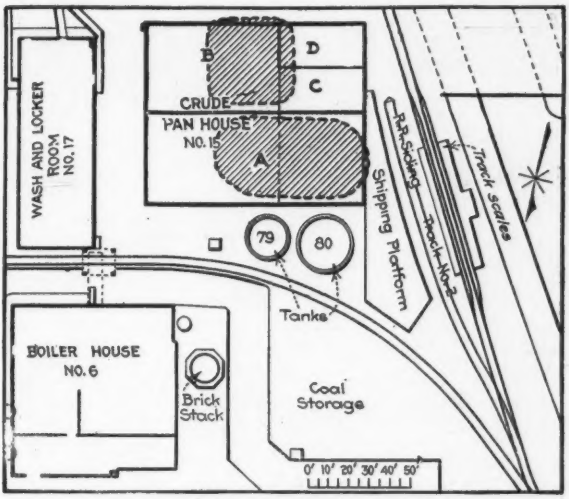
All of the eight fires caused by lightning could have been prevented by properly installed lightning arresters. In one case a 66,000 volt aluminum arrester failed and the line grounded igniting the oil. In the other seven cases there was apparently no protection against lightning. Two of the transformer houses were destroyed, two were burned with heavy damage and four were but slightly damaged.

# Napthalin Fire Wrecks Concrete Building.

The *Engineering News Record* (member N. F. P. A.) has recently published a report on the Barrett Manufacturing Company fire at Philadelphia in June, 1920. This fire has already been briefly reported in the QUARTERLY when reference was made to the loss of life involved. The *Engineering News Record* gives interesting supplementary data, which through their courtesy is reprinted in full below.

Last June a reinforced-concrete building in the chemical plant of the Barrett Manufacturing Co., at Frankford, near Philadelphia, Pa., was wrecked by a high-temperature fire from burning naphthalin, a coal-tar product being stored in the building. Since then the owner has been studying the design of the structure, with a view to its rebuilding, and has preferred to withhold the details of the fire until some decision could be reached as to the proper design for such occupancy. It has now, however, released the following information regarding the building and fire. Part of this information was obtained in an inspection of the building last summer and part from papers read before the recent annual meeting of the American Concrete Institute.

The building in question was a two-story reinforced-concrete structure, 86 x 106 ft. in plan, and divided into two symmetrical parts by a 13-in. brick wall the long way of the building. The first floor was on the ground, and the second consisted merely of beams and girders with no floor slabs. This peculiar construction is due to the occupancy, that is, the cooling of naphthalin. The naphthalin is stored in large, flat pans resting directly on the beams and girders and at intermediate levels at each floor on wooden horses or trestles. The entire structure was of reinforced concrete, except two light monitor roofs, as shown in the cross-section herewith, of unprotected structural steel. The details of the reinforced-concrete design are shown in the accompanying drawings. The columns are square, 18 x 18 in. in the first floor and 12 x 12 in. in the second, and are reinforced with straight rods bound at 12-in. centers by light wire binders. The beams and girders are reinforced by a loose rod system,

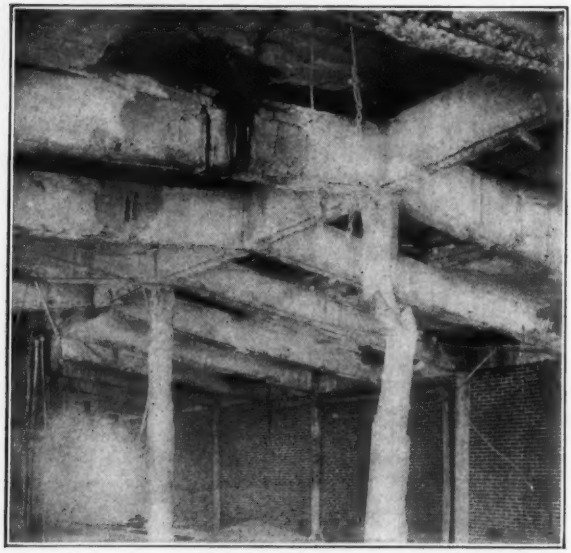



**Layout of Plant where fire occurred.**

heavily stirruped and with continuity rods extending well into girders and through the columns. Details of the roof itself are not available, but the structural steelwork is open to the second floor except at the monitors where there was a 3½-in. slab as shown over a part of the sloping roof between the monitors.

On one side of the building about 20 ft. distant from the wire-glass windows were two steel tanks in which naphthalin was stored. The fire started early in the morning and was apparently due to a "boil over" in one of these tanks. The molten material ran out into the yard of the plant and about 150 ft. distant into the boiler room, where it caught on fire and the fire ran back over the surface of the liberated naphthalin and soon distributed the flames to the naphthalin pans inside the building. The plant watchman was notified of the fire at 5:55 a. m., the naphthalin from the exploded tank being on the ground burning at that time. At 6:30 a. m. the destruction of the building was practically complete; that is, the building was brought to its final failure in about 45 minutes, which is an indication of the quickness and severity of the fire.

Due to the extreme heat generated by the flames there is very little reputable testimony as to the behavior of the structure during the conflagration. It is to be noted, however, that the steel monitors collapsed almost immediately the fire started inside the building, and, except for a portion of the building as shown on the plan, they carried down with them in their fall the full second story of the building. The fire also attacked the monitor farthest from the tank and that collapsed, causing destruction on the second floor of the section beyond the fire wall. Naturally, the heat was most intense in the section exposed to the tank and here the destruction of the concrete itself was most marked. On the side toward the tank, for instance, there is obvious evidence of fusion of the concrete, as shown in



**Typical failure in second floor.**

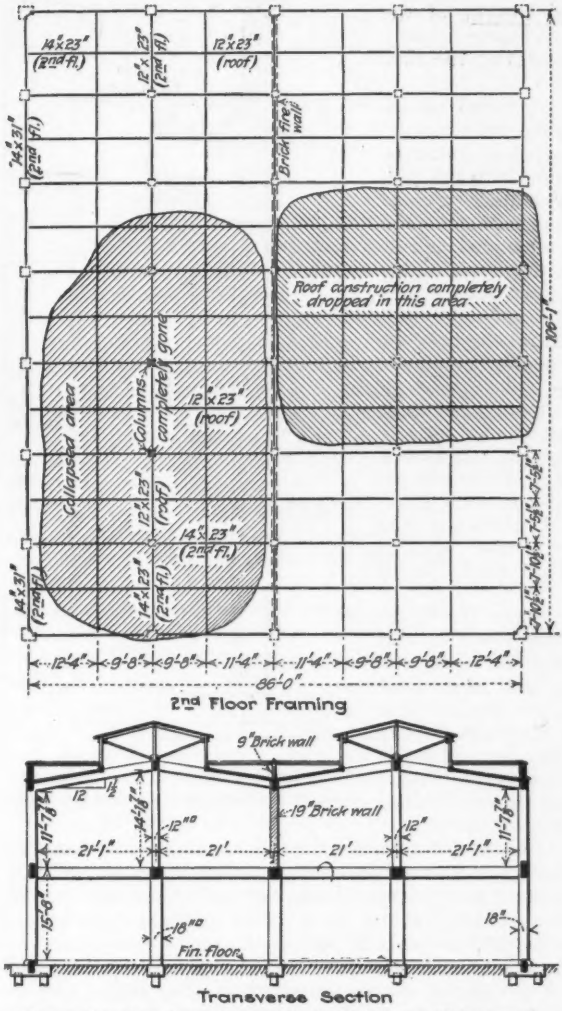
the accompanying view. There can be no question that the temperature at this place reached such a height as to cause fusion. In all previous fires, it may be noted, such an occurrence has been very rare. The steel mullions to the window frames here also melted and ran down the frames in places.

The typical failures are shown in some of the views. The columns spalled off on the corners, the reinforcement softened and bent and the columns cracked as shown. The edges of the beams also spalled, exposing the steel, which softened, bent and in some cases broke, dropping the beams. It is difficult to tell how much of the failure was due to the impact of the falling monitor and how much to direct fire damage.

### Comments by W. A. Hull.

Some of the comments on the design of the building and on the probable design of another building for the same occupancy are taken, as follows, from a paper by W. A. Hull (member N. F. P. A.) of the U. S. Bureau of Standards:

The building was of modern design and recent construction. It may be regarded as a first-class reinforced-concrete building. However, in connection with the failure of the columns supporting the roof structure, attention should be called to the fact that computation shows that the unit stress on the concrete core of these columns, when a deduction of 2 inches all round is made for fire protection, is somewhat in excess of that ordinarily allowed in engineering practice. Assuming continuous beam action, which probably approximated the true condition, the reactions at the



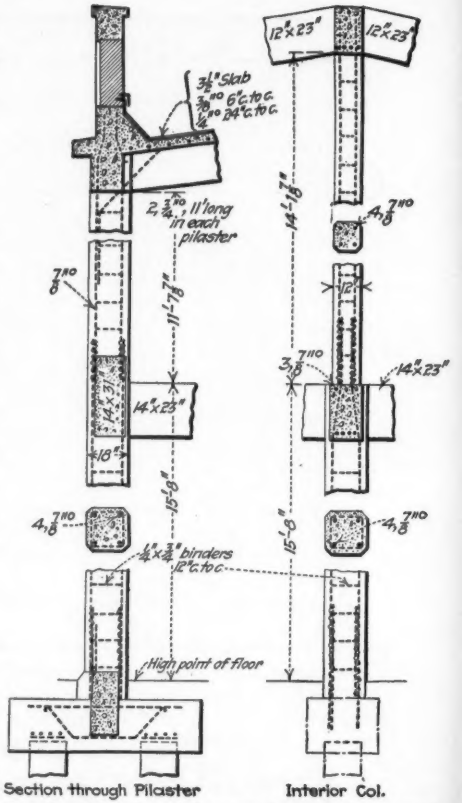

**Plan and section through Naphthalin Building which burned.**

center support are increased by 25 per cent. It should also be taken into consideration that the interior columns presumably expanded more than the wall supports when subjected to fire conditions and that this would still further increase the load sustained by these columns. All of the loads allowed for in computing the stress on the concrete in these columns, with the exception of approximately 15 per cent (the roof live load) were

due to the weight of the structure and were actually on the columns at the time of the fire.

The center roof girder was designed with the assumption that it would be fully continuous, which perhaps represented actual conditions except in the end spans for which no details are shown. The roof beams were designed for a bending moment of 1/10 WL which is ordinary practice for continuous beams of two spans. The maximum diagonal shearing stress in both beams and girders was about 60 lb. per square inch, and what would be considered adequate additional web resistance was provided in the form of bent-up bars and light stirrups.

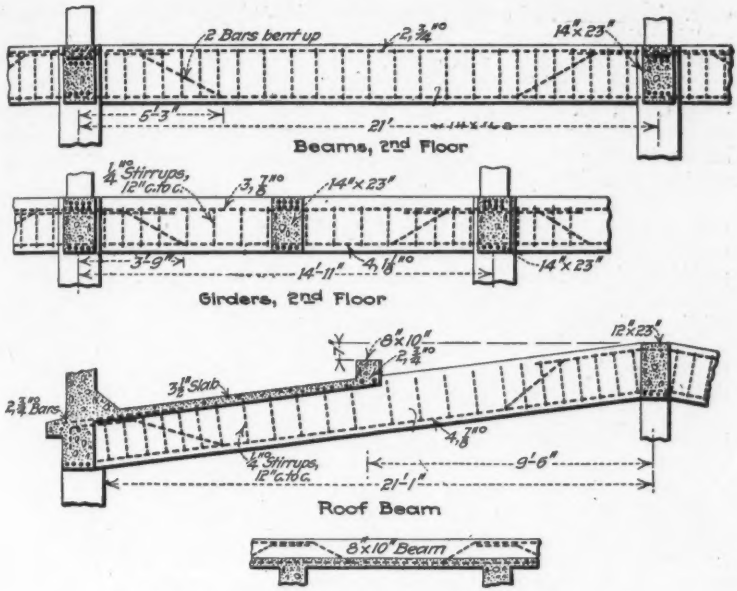
The coarse aggregate used in the concrete was gravel obtained from the Delaware River near Bridesburg. There was nothing extraordinary about this aggregate; it would properly be classed as a highly siliceous rather than a lime-stone gravel.




**Details of Reinforced Concrete Framing in wrecked building.**

The failure of this building to withstand the attack of the fire presented the engineers of the Barrett company with a new problem, or rather with a series of new problems, for they had to consider not only the reconstruction of this building but also the question of safeguarding other buildings, already in use, in which unusual fire hazards exist. This building had been built according to good practice in design and construction and was regarded as the last word in fire-resistive construction, yet it had failed to resist the attack of a severe fire. It is needless to say that the owners of this building expect to be able to prevent a recurrence of such a fire in the new building but they realize that they have a hazardous occupancy and that there is the possibility of another fire in spite of all precautions. The question of how to build at reasonable cost a building that would be able to withstand such a fire had to be answered.

Many things were considered. The advisability of rebuilding in concrete was seriously questioned. Such expedients as substituting brick




**Details of Reinforced Concrete Framing in wrecked building.**

piers for concrete columns and of protecting the concrete structural members with burned clay in some form were considered. It was a case that could not be disposed of by saying that nothing could be expected to withstand such a fire. If the best concrete construction were not going to be suitable it was obviously necessary to try to find something else that would. However, a careful analysis of the matter brought out the fact, very strikingly, that the building that was damaged, although first-class in every other respect, was absolutely unsuited to the resistance of a quick, sharp fire, and that the results did not differ widely from what was to be expected of this type of structure. The fact was also brought out that the failure of this building did not justify the conclusion that concrete construction is not suitable for such an occupancy.

It is the writer's understanding that the engineering staff of the Barrett company decided to rebuild in concrete, although because of prevailing business conditions the structure has not yet been replaced. It may be worth while, however, to review some of the points which led to the conclusion to rebuild in concrete.

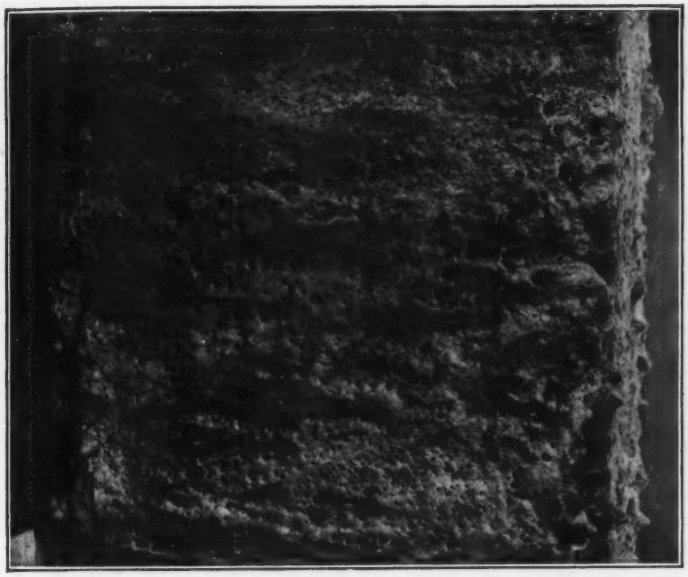
As has already been stated, this building, first-class in other respects, was by no means of the best type of fire-resistive construction that can be built, within reasonable cost limits, of reinforced concrete. In the first place, the gravel aggregate used in this building belongs in the class of aggregates that have a strong tendency to spall when exposed to quick fires. The square columns and rectangular girders made spalling relatively

easy. There was, of course, nothing provided in the way of metal mesh or other tie, to prevent the loss of the protective concrete by spalling. It has been demonstrated repeatedly, by actual fires and by fire tests, both in this country and in England, that this type of concrete building does not resist quick, hot fires well. This is the second notable case in which such construction has failed after a comparatively short exposure. There have been a number of other cases which have been less spectacular and have received little if any publicity.

In the case of the Far Rockaway fire and of the one at Frankford the process of destruction was essentially the same. Large portions of the outer protective concrete spalled off, leaving the load bearing concrete and portions of the reinforcement exposed directly to the fire. Neither steel nor load bearing concrete is adapted to withstanding such exposure, and this is particularly true of concrete made from a highly siliceous aggregate. In the case of the Far Rockaway fire it seems reasonably certain that had the building been identical in all respects except aggregate with the building that was so badly damaged it would have come through the fire without structural injury. In this case the same construction would have "got by" if the concrete had been of a non-spalling type made with a coarse aggregate of limestone, trap rock, or blast furnace slag. With the Frankfort fire the case is not so clear, but it is certain that a non-spalling concrete would have resisted much better; whether the building would have endured without serious structural damage if it had been built exactly as it was, except that more suitable aggregate had been used, is a matter of opinion. At any rate the fact that it did not endure is not to be regarded as proof that no type of construction could be expected to endure through such a fire, or that it would be advisable to depart from reinforced-concrete construction in building to house such an occupancy. The type of construction as well as the aggregate was poorly adapted to resist spalling and other structural damage. The long, slender, square columns and long girders without special ties for the protective concrete made the building particularly liable to such effects.

In many localities a non-spalling aggregate can be used without excessively increasing the cost of the building. Limestone, either crushed or in the form of limestone gravel, as well as trap rock and blast furnace slag are all so definitely superior to siliceous gravels, crushed sandstone and crushed granite as to make two distinct classes of aggregates, which for brevity have been called spalling and non-spalling. Where the cost of a non-spalling aggregate is excessive the severe fire hazard can be met by the use of secondary reinforcement in the outer concrete together with a reasonable increase in the thickness of the latter. The effectiveness of secondary reinforcement in the form of a light grade of expanded metal placed in the protective concrete has been tried out in fire tests of full sized building columns with promising results. There appears to be no reason for doubting that the fire-resistance of girders and slabs made from the spalling types of aggregate could be brought up to any reasonable standard by the proper use of secondary reinforcement with protective concrete of suitable thickness.

The lessons to be learned from the Barrett fire seem to be fairly well defined. If we accept the evidence of the column tests that have been conducted within the last three years at Chicago and at Pittsburgh there can



**A specimen of fused concrete beam.**

be no doubt that reinforced-concrete buildings that will be very greatly superior to the Barrett building in point of fire-resistance can be built without too radical departures from established engineering practice.

### American Concrete Institute Report.

In the report of the committee on the Far Rockaway fire, of the American Concrete Institute, is the following comment on the Barrett fire: The progress of the fire was extremely rapid. At the beginning, Tank 79 was burning; Tank 80, having a wooden top, soon caught fire and was entirely consumed. The fire spread to Building No. 15, known as the "Pan House," where the material, in Section A (east of the dotted line, which represents a temporary wooden partition), lay in long cooling pans. West of this partition was the "flake house," where the material existed in a flocculent condition and was spread over the roof, beams and sides of walls. In addition to Tank No. 79, Building No. 17, the coal storage, the roof of Building No. 6 and the awnings on Building No. 5 were ablaze at the start.

In Section B, the second tier columns were all damaged, and will probably have to be removed. Section C is in pretty fair condition. Section D, known as the centrifugal room, was only slightly damaged. The fire wall separating these three sections from Section A probably protected sections B, C and D from damage. The shipping platform was destroyed, as was also the hose house in front of Building No. 2. The hollow radial brick stack of the boiler house was damaged to a height of about 30 feet.

Considerable spalling took place and it was necessary to plaster the stack for a distance of 30 feet from the ground. Building No. 17 was entirely destroyed, and the roof of Building No. 6 was seriously damaged.

The very rapid and intense heat that resulted from the burning of this naphthalin, especially in Building No. 15, which had no floors, but had a double tier of long, cooling pans, containing naphthalin, which burned freely, subjected the concrete to very rapid expansion, and caused the serious spalling of the corners of the columns and edges of beams, exposing the reinforcement in nearly all cases and in one of the columns the exposure was sufficient to cause buckling of the column. The rigidity, however, of the roof construction was sufficient even under this severe treatment to keep it in place, excepting the western end of Section A. Failure was caused by the collapse of the unprotected metal lantern. The north end of the building, facing Tanks No. 79 and 80, was subjected to very unusual heat and the face of the brick walls spalled under the action of this heat for the distance of nearly an inch. The wired glass in the windows melted and even the metal muliions were melted. The flames from the burning naphthalin in the cooling tanks roared through this opening and fused the adjacent concrete faces of the beams and girders even on the exterior of the columns. The columns in this building were square in section and spalling occurred. The round type of column would have materially helped the situation, but in the judgment of the committee would not entirely have prevented spalling.

From this fire are drawn the following conclusions :

(a) The spalling of the concrete was in large measure due to the use of a coarse aggregate which contained a large percentage of quartz;

(b) Square columns increased the degree of spalling;

(c) Structural concrete requires protection against fire; the thickness of the protective coating depends on the degree of heat to which the structure is likely to be subjected;

(d) It is probable under these conditions that 2½ inches of concrete, made of aggregate of non-spalling character and properly reinforced, would afford adequate protection to the structural concrete;

(e) The sprinkler system was rendered inefficient by the shutting off of the electric current which operated the pumps;

(f) The engineers of the Barrett company are of the opinion that there is no more suitable material for use under such conditions than reinforced concrete, and will, therefore, use this material in reconstruction.

**Note.**

One interesting feature of this fire not mentioned in this article is given in a report from another source. It is reported that the private fire brigade at this plant had ten private hose streams in operation, supplementing the thirty-five streams furnished by twenty steamers of the public department. These ten private streams, supplied by the plant fire pump system, were a material assistance to the public fire department. Fairly good headway was apparently being made against the fire when, about fifteen minutes after the arrival of the firemen, transformers fastened on wooden poles outside the boiler house fell to the ground, leaving live wires carrying 2200 volts flying around loose. The electric company was notified, and shut off the current from the plant, including the electric pumps. Thus the ten private streams were out of commission for about half an hour.—ED.

# Every Roomer an Exposure.

A conflagration involving twenty-one buildings destroyed the business district of Moore Haven, Florida, on April 27. The landlady of a rooming house was ironing with a gasoline iron, when she attempted to refill it while hot. The can of gasoline ignited, blowing off one or more of her fingers and scattering burning gasoline over her clothes. She died the next morning.

The Glades Loan and Investment Co. of Moore Haven have reported this fire on one of the N. F. P. A. standard report forms, and in addition to the usual routine information give the following:

"Answering the twenty-five questions at bottom of sheet.

"No. 1. Construction—was all good 'fat pine' wood and burned fastest possible.

"Questions No. 2 and No. 6 don't apply to this fire—as it was a number of small buildings.

"No. 7. Exposure—Every roomer in the rooming houses was an exposure—also every store—it was ALL exposure.

"No. 8. Occupancy—Most of burned district was stores on first floor and rooming houses on second floor. The occupants of the latter were a conglomeration of all kinds of people that come here at this time of the year to pick and pack tomatoes.

"The lady that caused the fire was manager of one of these rooming houses—and was considered very nice—and responsible.

"When the gas can exploded—she yelled—afterwards the fire bell was rung.

"Fire hose was brought into action but there was but little pressure from the town tank—there being only a 2-inch pipe.

"Two streams were played on the fire—but too late. It just burned itself out.

"Wind was blowing quite strong and shifted two or three times during the fire.

"The people turned out and much merchandise was piled in the street that was afterwards burned when the wind shifted.

"The Mayor put out extra police and but little, if any, looting was done.

"As adjusters have been here, their report will show the loss and insurance much better than can this report.

"It's just another case of mushroom town built up of wood—going, as they all go.

"We will now proceed to build to stay—for KEEPS.

"The bit of insurance will help—but the big tomato crop now being harvested is what is going to rebuild our town, so that it won't burn—and the only town in the Everglades will be the better off for having had a cleaning."

# New Orleans Sunday School Fire.

**Report by Louisiana Fire Prevention Bureau.**

**(Member N. F. P. A.)**

The Sunday School and Parish House of the Jackson Avenue Evangelical Sunday School was a brick, two story, slate, joisted construction, building, 50x100 feet, erected for present occupancy in 1911. It was occupied as a Sunday School and for entertainments relating thereto. Walls were of brick, 12, 12 inches, lath and plaster finish on furring strips; ordinary openings all sides, parapeted above roof 2 to 2½ feet, with metal cornice. Second floor was of wood, upheld by iron posts, lath and plaster finish beneath. Stairways, inside, open, from vestibules on both floors. Adjoining main building was a small brick, one story, slate roof bathroom, 15x15, connected to main building by ordinary frame door. There was no private fire protection in building. Heating was from wood stoves and small gas heaters; lights were electric, wires concealed in flooring.

Fire was discovered at 2:07 P. M., March 7, 1921, and the public fire department was first called over the telephone by citizens, followed by public fire alarm box No. 143, then general alarm was turned in. Fire Department responded promptly, 35 engines answering alarm, consisting of chemicals, pumps and ladder trucks. Fire was mostly confined to this

**Showing Percentage of Openings in Bearing Walls.**

**Showing collapsed wall and timber release.**

building proper, but other dwellings adjacent to this Parish House were damaged each to a small extent. The cause of the fire is unknown. It is generally attributed to defective wiring, but fuller investigation shows conclusively that such was not the case.

Four firemen were killed and one injured, in this fire, by the collapse of the walls of the main building onto the roof of the one-story addition within which they were fighting the fire through doorway to main building. This wall was of brick, 12 and 12 inches, 12-inch parapet with ordinary openings in each floor, comprising 62½% of the entire area, taken on horizontal section remaining 37½% comprising 8 piers, not pilastered or buttressed except by ordinary frame, lath and plaster cross walls, and averaging 4 ft. 9 in. by 12 in. thick. Lintels of these openings were of double brick header arches with 6-inch spring. Timbers into these bearing walls were self-releasing. Superimposed above the lintels of the openings on second story were 30 courses of brick, rising above the roof and forming parapet mentioned. The cause of the collapse can readily be seen. Fire originated within the building, burning away the frame cross walls, reaching the roof; floor joists and roof timbers released cleanly, leaving this wall, with the heavy superimposed load of brick totally unsupported. Pressure, due to expansion within, caused the wall to topple over with fatal results as noted.

National Board Building Codes of 1905, 1907, 1909, Part VI, Section 28, referring to bearing walls with openings requires that, "If any horizontal section through any part of any bearing wall of any building shows more than thirty per centum area of flues and openings, the said wall shall be increased 4 inches in thickness for every fifteen per centum or fraction

thereof of flue or opening area in excess of thirty per centum." We may presume that the above provision was overlooked through inadvertence or perhaps not fully realizing the full importance of this requirement.

We call attention to Section 26, paragraphs 11 and 12, of the current issue (1920), Building Code of the National Board of Fire Underwriters, which says: "11. If any horizontal section through a bearing wall shows more than 30 per cent area of flues and openings in a wall laid up in lime, or lime and cement mortar, or 45 per cent in a wall laid up in Portland cement mortar, the said wall shall be increased a thickness of 4 inches for every 15 per cent or fraction thereof for which the total area of flues and openings exceed 30 per cent, or 45 per cent. The total area of openings and flues in any bearing wall shall not in any case exceed 60 per cent. 12. In all buildings, walls 12 inches thick and over 60 feet in length; and walls 16 inches thick which are over 100 feet in length, shall be 4 inches thicker throughout than is required by this Code unless they are properly braced by cross walls, pilasters or buttresses."

The fatal results of this fire can be attributed first, to faulty building construction and to lack of appreciation or understanding of what constitutes ordinary precaution and safe construction; and, second, to the same lack of appreciation of the dangers of such construction by firemen in the handling of fires in hazardous buildings.

# Niagara Sprayer Co. Fire.

**Report by L. H. Eaton.**

The fire which damaged the brimstone (sulphur) refinery, known as Building No. 24, of the Niagara Sprayer Co., Middleport, N. Y., on March 4, 1921, is interesting because of the fact that although the sulphur dust hazard was safeguarded by an atmosphere of inert gas, fire apparently spread with explosion-like rapidity through the dust-collecting system. The fire was entirely confined to the building of origin, with a loss moderate in comparison to the value of the entire plant.

### Processes and Apparatus.

A section of the northeast corner of Building 24 is separated from the remainder by brick walls with openings, each floor protected by ordinary wood doors. The 2nd and 3rd floors in this building are of brick arch construction, with concrete-wearing floors. The roof is of laminated 2 x 6s on unprotected steel truss. Sulphur is brought into the first floor of the building and emptied into a hopper, feeding ordinary bucket elevator, wood-enclosed, which extends through the 2nd floor, delivering the sulphur to the grinding mill. It is ground and dropped back to the first floor, passing through a gear-driven rotary shutter valve. There is also an explosion vent, opening to the outside, located between the mill and this shutter valve. Ground sulphur is run into bags which are taken a distance of perhaps 10 feet and emptied into a hopper of another frame-enclosed bucket elevator, which extends through the 3rd floor. This discharges the sulphur to a horizontal worm conveyor which passes through the brick

wall, separating this room from the west section, and flows by gravity to two frame Dunlop bolters, located on the ground floor in the northwest section. Fan driven by a 220-volt induction motor is located on the 3rd floor. This fan is connected by metal pipes to the heads of the elevators, to both the bolters, and through a long run of horizontal pipe to the sulphur bin located in the northeast corner of Building 24. This fan draws the dust from these points and forces it through a multiple muslin bag dust-collector, located near the fan. The dust collected is discharged to a barrel at the end of the dust collector. *All processes are carried on in a neutral atmosphere of carbon dioxide gas and nitrogen,* the gas being supplied by a modern system recently installed with a gas-producer located in the central section of this building. An open spiral stairway extends from the 1st to 3rd floors in the northwest corner of the northeast section.

**Conditions at Time of Fire.**

The grinding mill and elevator to grinding mill were operated during the morning until 11 o'clock. They were then stopped and the bolters started, together with elevator driving the sulphur to the bolters. These had been running continuously to the time of the fire, with the exception of the noon hour. The fan for the dust-collector had been in continuous operation during the day, except at the noon hour. The bell gas holder supplying carbon dioxide to the apparatus was nearly full and was apparently functioning properly.

**The Fire.**

At approximately 4:45 P. M. fire was noted at three different points at approximately the same time. The man having charge of the bolters was on the elevated platform near the bolters. He reports that he heard a rumbling noise, so closely followed by a flash that he was not able to definitely state which occurred first. He jumped from the platform and ran to the door. A man was located on the 2nd floor of the northeast section. He reports that a flash or flame appeared at the stairway to the 3rd floor. At about the same time it was reported that there was also a flash near some sulphur bags located near the discharging device in the grinding mill. The fire spread rapidly in the 3rd floor of the northeast section and around the frame bolters of the northwest section. A 40-gallon chemical extinguisher was used with good effect on one of the bolters, nearest the door. 2½ gallons of chemicals were brought from other buildings and used on the fire, as well as two 1-inch hand hose, which were used normally in process work. An alarm was sent to the village fire department, who responded promptly. They laid a line of hose from a private hydrant located on the east side of Building 25. Estimated about twenty minutes elapsed between the start of the fire and getting water on it from this hose line. Pressure was ample and hose stream effective in extinguishing fire, in the building around the apparatus, within approximately twenty minutes. The sulphur, however, continued to burn for some time and water was played on this for approximately two hours.

**The Damage.**

The damage to the building was confined largely to the section of the roof over the northeast portion of the risk, which was deeply charred, and

to the windows in this room, and to the windows near the frame bolters in the northwest section, which were all broken. The roof over the northwest section was badly smoked and somewhat charred. The dust-collector was entirely destroyed. The motor was badly damaged and the fan entirely demolished, all except one of the blades being broken. The bolsters were badly burned, both probably being a total loss, although a portion of the wood framework of the one on which the 40-gallon chemical extinguisher was played, was not burned. Considerable quantities of stock on the first floor of both sections were destroyed. The boards of the elevator boot delivering the sulphur to the bolters, were loosened, both on the 3rd floor and the 1st floor, although there was no evidence of fire inside of this boot, there being a fine coating of sulphur dust on the interior, which was not even scorched at these points. The two boards of the elevator delivering sulphur to the mill, were also loosened at the first floor, and while there is slight evidence of the charring of sulphur inside this boot, it is probable that this occurred after the explosion, and did not accompany it.

**Conclusion.**

It will be noted from the previous description, that the two elevator systems are independent, the only connection between them being through the pipes collecting the dust and discharging through the fan to the dust collector, and through the pipes delivering carbon dioxide gas to the two heads of the elevators, as well as to the other apparatus. In as much as the fire and explosion was noted simultaneously at three points, it would appear that either the dust collecting system or the gas delivery system was responsible for the propagation of the explosion and flame to these points.

The pipe delivering gas is of small diameter and even if by any probability there had been present some carbon monoxide in the gas, it is probable that if this had caused the trouble that it would have extended back to the gas holder, and a serious explosion here resulted. It would seem, therefore, that the dust collecting system alone was responsible. While it is possible that the fire might have originated in the bolters or in the elevator conveying the sulphur to the bolters and been drawn from these to the fan, and from here spread to the elevator delivering sulphur to the mill, this possibility seems remote. Bolters of this type have been in use in another plant of this company for many years and no trouble has ever been experienced in connection with them.

With these possibilities eliminated, all things would indicate that the trouble originated in the fan itself. This fan with metal blades was driven at a high speed. It is possible that the rivets holding one of these blades became loose, or that the shaft carrying the blades got out of alignment enough to cause the blades to hit the casing, striking a spark and stopping the fan. This spark would probably cause a slight explosion, which would be propagated through the dust collector pipes to the various pieces of apparatus.

It is recommended that on re-installation, that in so far as possible, dust-collecting system to the various pieces of apparatus be kept independent to one another, and that pressure relief vents be provided in the dust-collecting lines.

# Secondary Supplies for Sprinkler Systems.

The two tables below are an addition to the annual sprinkler fire tables. The data is taken from the same fire records but has never before been presented in the tables. These new tables show that in 1216 cases out of the 21,557 sprinkler fires recorded from 1897 to 1921 a secondary water supply was a factor. Reports giving insufficient data or showing that both water supplies were rendered useless by a closed valve, explosion, etc., are not included. Table I shows in general what the primary and secondary water supplies were for these 1216 fires. Table II gives the classification by industries. It is probably reasonable to assume that the greater the fire hazard of an industry, the more often the secondary supply would be called on to help extinguish the fire. This seems to be borne out by the table. The more hazardous of the chemical industries, such as chemical plants, cotton seed oil mills, distilleries, fertilizer plants, glue factories, lead works, linseed oil works, oil cloth and linoleum plants and oil refineries, show that the per cent of the total fires where the secondary supply was a factor ranges between 12.9 and 36.8 with an average of 20.6%. Other industries of this class, such as drug houses, dyeing, bleaching and finishing plants, oiled clothing factories, paint factories, soap factories, show a lower percentage, averaging 4.6%.

The textile and fibre industries also divide into two groups. Bag factories, cotton mills and warehouses, cordage works, and woolen mills, show an average of 8.5% fires requiring a secondary supply. Others, such as clothing, knitting, shirt manufacturing, shoddy, waste and batting, weaving mills, worsted mills, carpet mills, mattress factories and hatters fur, show an average of only 3.3%. The metal-working industries divide into bolt, nut and screw works, insulated wire works, rolling, wire and tube works, stamping and sheet metal works with an average of 7.2%, as compared with automobile and bicycle factories, car works, electrical appliances, foundries, garages, metal workers, and machine shops with an average of 2.2% of fires requiring a secondary supply.

Other industries showing a high per cent of fires requiring a secondary water supply are grain elevators, munition factories, pulp mills and sawmills. These industries are all of considerable fire hazard.

## Fire Record.

A few typical fires where a secondary water supply was a factor are described below:

**21708. Glue Factory.** This fire took place in a hide glue works and would have resulted in a considerable loss if it had not been for the secondary sprinkler supply. Lightning struck the roof of the cooler house while the workmen were at lunch. The blowers were immediately shut down and the fire pump started. The gravity tank, which was the primary supply, had been emptied during the forenoon so that the circulating heater connection could be repaired. It was noticed that no water was coming

from the sprinklers although the steam pumps had been started. It was found that a drain valve was open and as soon as this was closed a pressure of 60 to 80 pounds was obtained. The fire had already destroyed the monitor of the cooler house and was burning the roof of monitor at front of the glue-spreading room. The sprinklers soon checked the fire and it was subsequently extinguished with hose streams. 211 sprinkler heads opened and the three service pumps aggregating about 1,400 gallons per minute pumping capacity kept up a heavy flow after the drain was closed.

**29260. Mercantile.** Fire occurred in a retail clothing store late in the afternoon. It is believed to have been set by an incendiary and the primary supply to the sprinklers had been purposely shut off. The fire started in the basement and had gained considerable headway when the fire department connected to a steamer connection and pumped water into the sprinkler system, extinguishing the fire. All of the twenty-two sprinklers in the basement had opened.

**29311. Printing Establishment.** Fire started from unknown cause in a shipping shed adjoining the varnish machine building. It was burning fiercely when noticed by the watchman, who promptly notified the fire department. When they arrived the fire was being driven by a strong wind and had completely enveloped the outside of one end of the varnish machine building. The firemen after a hard fight succeeded in getting the fire under control. In the meantime, ten sprinklers in varnish machine building, four in the cutting and folding building, and one in the ink-mixing building were operating and kept the fire out. This is quite worthy of note, as the fire was intense, the roof and walls being almost burned through from the outside, and yet the contents were practically untouched. The light wood roof beams were not even scorched except at the eaves, where the fire worked along about one foot on each side. As soon as the fire department began to draw from the public mains, this supply was no

**Table I.**

**Secondary Supplies to Sprinkler System.**

| Primary Supply | No. of Fires where Secondary Supply was a Factor | Secondary Supply: Waterworks | Gravity Tank | Pressure Tank | Steam Pump | Misc. Pump* | Steamer Connection |
|---|---|---|---|---|---|---|---|
| Water Works . . . | 339 | 8 | 97 | 5 | 151 | 63 | 15 |
| Gravity Tank . . . | 603 | 28 | 2 | 2 | 384 | 177 | 10 |
| Pressure Tank . . . | 221 | 67 | 79 | 5 | 34 | 26 | 10 |
| Misc. Pumps* . . . | 53 | 13 | 26 | 2 | 6 | 5 | 1 |
| Total . . . . | 1216 | 116 | 204 | 14 | 575 | 271 | 36 |

*Miscellaneous pumps include water supplies reported as automatic steam pump, automatic electric pump, automatic fire pump, fire pump, rotary pump and pump with no designation of type.

## Table II.

### Secondary Supplies to Sprinkler System.

| Occupancy | Total No. of Fires | Secondary Supply: When a Factor | Secondary Supply: % Total | Primary Supply: Waterworks | Primary Supply: Gravity Tanks | Primary Supply: Pressure Tank | Primary Supply: Misc. Pumps | Secondary Supply: Waterworks | Secondary Supply: Gravity Tank | Secondary Supply: Pressure Tank | Secondary Supply: Steam Pump | Secondary Supply: Misc. Pumps* | Secondary Supply: Steamer Connection |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Agricultural Implements | 73 | 3 | 4.1 | 3 | .. | .. | .. | .. | .. | .. | 2 | 1 | .. |
| Auto and Bicycle Fac.. | 161 | 5 | 3.1 | 2 | 1 | 1 | 1 | 1 | 3 | .. | .. | 1 | .. |
| Bag Factories | 12 | 1 | 8.3 | .. | .. | 1 | .. | .. | 1 | .. | .. | .. | .. |
| Bakeries | 74 | 1 | 1.3 | 1 | .. | .. | .. | .. | 1 | .. | .. | .. | .. |
| Bolt, Nut and Screw Works | 26 | 2 | 7.7 | 1 | .. | .. | 1 | 1 | .. | .. | 1 | .. | .. |
| Boot and Shoe Shops | 641 | 12 | 1.9 | 8 | 3 | 1 | .. | 1 | 5 | 1 | 3 | 2 | .. |
| Broom Factories | 13 | 1 | 7.7 | 1 | .. | .. | .. | .. | 1 | .. | .. | .. | .. |
| Candy Factories | 127 | 5 | 3.9 | 1 | .. | 4 | .. | 3 | 1 | .. | .. | .. | 1 |
| Car Works | 105 | 1 | .95 | 1 | .. | .. | .. | .. | .. | .. | 1 | .. | .. |
| Carpet Mills | 222 | 5 | 2.3 | 3 | 2 | .. | .. | 1 | .. | .. | 3 | 1 | .. |
| Carriage Factories | 146 | 13 | 8.9 | 8 | 1 | 4 | .. | 2 | 6 | .. | 3 | 2 | .. |
| Celluloid | 167 | 10 | 6.0 | 8 | 1 | 1 | .. | .. | 4 | .. | 4 | 1 | 1 |
| Cereal Mills | 45 | 4 | 8.9 | 2 | .. | 2 | .. | .. | .. | 1 | 1 | 2 | .. |
| Chemical | 116 | 9 | 12.9 | 2 | 7 | .. | .. | .. | .. | .. | 7 | 1 | 1 |
| Clothing | 784 | 13 | 1.7 | .. | .. | 13 | .. | 1 | 9 | 1 | 1 | 1 | .. |
| Coffin Factories | 52 | 1 | 1.9 | .. | .. | 1 | .. | .. | 1 | .. | .. | .. | .. |
| Cooperage Plants | 80 | 6 | 7.5 | 1 | .. | 5 | .. | 3 | 3 | .. | .. | .. | .. |
| Cordage Works | 277 | 31 | 11.2 | 9 | 6 | 14 | 2 | 11 | 5 | .. | 10 | 3 | 2 |
| Cork Factories | 24 | 1 | 4.2 | .. | 1 | .. | .. | .. | .. | .. | 1 | .. | .. |
| Cotton Mills | 4602 | 349 | 7.6 | 56 | 285 | 7 | 1 | 4 | 9 | .. | 236 | 100 | .. |
| Cotton Warehouses | 249 | 21 | 8.4 | 4 | 17 | .. | .. | 1 | 2 | .. | 14 | 4 | .. |
| Cotton Seed Oil Mills | 67 | 14 | 20.9 | 1 | 11 | 1 | 1 | 1 | 1 | .. | 10 | 2 | .. |
| Department Stores | 437 | 9 | 2.1 | 2 | 3 | 4 | .. | .. | 3 | 1 | 1 | 3 | 1 |
| Distilleries | 10 | 3 | 30.0 | .. | 1 | 1 | 1 | 1 | .. | 1 | 1 | .. | .. |
| Drug Houses | 184 | 9 | 4.9 | 4 | .. | 5 | .. | .. | 7 | .. | .. | .. | 2 |
| Dyeing, Bleaching and Finishing | 195 | 6 | 3.1 | 2 | 4 | .. | .. | 1 | .. | .. | 4 | 1 | .. |
| Electrical Appliances | 189 | 4 | 2.1 | 3 | .. | 1 | .. | .. | .. | .. | 3 | 1 | .. |
| Electric Light and Power | 8 | 1 | 12.5 | .. | 1 | .. | .. | .. | .. | .. | 1 | .. | .. |
| Elevators, Grain | 63 | 17 | 27.0 | 2 | 5 | 8 | 2 | 2 | 1 | .. | 8 | 6 | .. |
| Fertilizer Plants | 37 | 7 | 19.0 | 1 | 2 | 3 | 1 | 1 | 2 | .. | 3 | 1 | .. |
| Flour Mills | 88 | 9 | 10.3 | 2 | 3 | 4 | .. | 3 | 1 | .. | 2 | 2 | 1 |
| Foundries | 187 | 5 | 2.7 | 3 | 2 | .. | .. | 1 | 1 | .. | 3 | .. | .. |
| Furniture Factories | 666 | 46 | 6.8 | 21 | 8 | 16 | 1 | 9 | 16 | .. | 13 | 5 | 3 |
| Garages | 159 | 2 | 1.3 | .. | .. | 2 | .. | .. | 2 | .. | .. | .. | .. |
| Glass Works | 80 | 4 | 5.0 | 2 | .. | 2 | .. | .. | 2 | .. | 1 | 1 | .. |
| Glove Factories | 10 | 1 | 10.0 | 1 | .. | .. | .. | 1 | .. | .. | .. | .. | .. |
| Glue Factories | 10 | 2 | 20.0 | .. | 2 | .. | .. | .. | .. | .. | 2 | .. | .. |
| Harness and Fancy Leather | 94 | 3 | 3.2 | .. | .. | 3 | .. | .. | 3 | .. | .. | .. | .. |
| Hat, Fur | 82 | 2 | 2.4 | 1 | 1 | .. | .. | .. | 1 | .. | 1 | .. | .. |
| Hat, Straw | 43 | 2 | 4.7 | .. | 1 | 1 | .. | 1 | .. | .. | .. | .. | 1 |
| Hatters' Fur Mfg | 21 | 1 | 4.8 | 1 | .. | .. | .. | .. | 1 | .. | .. | .. | .. |
| Inc. Lamp Factories | 24 | 1 | 4.2 | .. | 1 | .. | .. | 1 | .. | .. | .. | .. | .. |
| Insulated Wire Factories | 38 | 2 | 5.3 | .. | 2 | .. | .. | .. | .. | .. | 2 | .. | .. |
| Junk Shops | 18 | 1 | 5.6 | 1 | .. | .. | .. | .. | 1 | .. | .. | .. | .. |
| Knitting Mills, Cop Yarn | 61 | 2 | 3.3 | .. | 2 | .... | | .. | .. | .. | 1 | 1 | .. |

## Table II.

### Secondary Supplies to Sprinkler System

| Occupancy | Total No. of Fires | Secondary Supply: When a Factor | Secondary Supply: % Total | Primary Supply: Waterworks | Primary Supply: Gravity Tank | Primary Supply: Pressure Tank | Primary Supply: Misc. Pumps | Secondary Supply: Waterworks | Secondary Supply: Gravity Tank | Secondary Supply: Pressure Tank | Secondary Supply: Steam Pump | Secondary Supply: Misc. Pumps* | Secondary Supply: Steamer Connection |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Knitting Mills, F. P. | 584 | 26 | 4.45 | 5 | 20 | 1 | .. | 1 | 1 | .. | 12 | 12 | .. |
| Linseed Oil Works | 25 | 4 | 16.0 | .. | 2 | 2 | .. | .. | .. | .. | 1 | 3 | .. |
| Lead Works | 6 | 1 | 16.7 | .. | 1 | .. | .. | .. | .. | .. | .. | .. | 1 |
| Machine Shops | 377 | 10 | 2.65 | 1 | 3 | 6 | .. | 1 | 2 | .. | 6 | 1 | .. |
| Match Factories | 63 | 4 | 6.35 | .. | 1 | 1 | 2 | 3 | .. | .. | .. | 1 | .. |
| Mattress Factories | 404 | 14 | 3.5 | 1 | 7 | 6 | .. | 3 | 3 | .. | 7 | .. | 1 |
| Mercantile | 845 | 30 | 3.5 | 3 | 1 | 24 | 2 | 12 | 7 | 1 | .. | 3 | 7 |
| Metal Workers | 917 | 27 | 2.9 | 12 | 8 | 6 | 1 | 3 | 5 | 1 | 15 | 2 | 1 |
| Miscellaneous | 536 | 24 | 4.5 | 11 | 5 | 6 | 2 | 2 | 8 | 1 | 9 | 4 | .. |
| Morocco Leather | 47 | 2 | 4.2 | 2 | .. | .. | .. | .. | .. | .. | 1 | 1 | .. |
| Motion Picture | 53 | 2 | 3.8 | 1 | 1 | .. | .. | .. | .. | 1 | 1 | .. | .. |
| Munition Factories | 43 | 9 | 21.0 | .. | 9 | .. | .. | .. | .. | .. | 9 | .. | .. |
| Musical Instrument Factories | 154 | 6 | 3.9 | 2 | 1 | 3 | .. | .. | 4 | .. | 1 | 1 | .. |
| Office Buildings | 16 | 2 | 12.5 | 1 | 1 | .. | .. | 1 | 1 | .. | .. | .. | .. |
| Oil Clothing Factories | 15 | 1 | 6.7 | .. | .. | 1 | .. | 1 | .. | .. | .. | .. | .. |
| Oil Cloth and Linoleum | 98 | 36 | 36.8 | 9 | 24 | .. | 3 | 4 | 4 | .. | 21 | 7 | .. |
| Oil Refineries | 15 | 2 | 13.4 | .. | 1 | 1 | .. | 1 | .. | .. | 1 | .. | 1 |
| Packing House | 144 | 9 | 6.25 | 5 | 2 | 2 | .. | 1 | .. | .. | 3 | 4 | .. |
| Paint and Color Works | 195 | 11 | 5.65 | 1 | 2 | 8 | .. | 4 | 2 | .. | 4 | 1 | .. |
| Paper Box | 179 | 5 | 2.8 | 1 | 1 | 3 | .. | 1 | 1 | .. | 1 | .. | 2 |
| Paper Mills | 528 | 50 | 9.5 | 14 | 30 | 1 | 5 | 3 | 2 | .. | 30 | 15 | .. |
| Picture Frames | 51 | 4 | 7.8 | .. | 1 | 3 | .. | .. | 2 | 1 | 1 | .. | .. |
| Plaster Works | 2 | 1 | 50.0 | .. | 1 | .. | .. | .. | .. | .. | .. | 1 | .. |
| Plumber's Supplies | 23 | 2 | 8.7 | 1 | .. | 1 | .. | .. | 2 | .. | .. | .. | .. |
| Potteries | 60 | 2 | 3.3 | .. | 1 | .. | 1 | .. | 1 | .. | 1 | .. | .. |
| Printing | 586 | 6 | 1.0 | .. | 3 | 3 | .. | 2 | 2 | .. | 1 | .. | 1 |
| Pulp, Miscellaneous | 26 | 4 | 15.4 | 3 | 1 | .. | .. | .. | .. | .. | 4 | .. | .. |
| Pulp, Soda | 2 | 1 | 50.0 | .. | .. | .. | 1 | 1 | .. | .. | .. | .. | .. |
| Pulp, Sulphite | 36 | 7 | 19.5 | 4 | 2 | 1 | .. | .. | .. | .. | 6 | 1 | .. |
| Rolling, Wire and Tube Works | 30 | 2 | 6.7 | 1 | 1 | .. | .. | .. | .. | .. | 1 | 1 | .. |
| Roofing Works | 47 | 7 | 14.9 | 3 | 4 | .. | .. | .. | 2 | .. | 4 | .. | 1 |
| Rubber Cloth Factories | 41 | 2 | 4.4 | 1 | 1 | .. | .. | .. | .. | .. | 1 | 1 | .. |
| Rubber Reclaiming Works | 13 | 2 | 15.4 | .. | 2 | .. | .. | .. | .. | .. | 2 | .. | .. |
| Rubber Works | 196 | 8 | 4.1 | 2 | 5 | 1 | .. | 1 | .. | .. | 2 | 4 | 1 |
| Saw and Planing Mills | 163 | 33 | 20.1 | 13 | 12 | .. | 8 | 2 | 6 | .. | 16 | 8 | 1 |
| Shirt Factories | 44 | 1 | 2.3 | 1 | .. | .. | .. | .. | .. | .. | .. | 1 | .. |
| Shoddy Mills | 270 | 13 | 4.8 | 9 | 3 | .. | 1 | .. | 2 | .. | 8 | 3 | .. |
| Skin Mills | 4 | 1 | 25.0 | 1 | .. | .. | .. | .. | .. | .. | .. | 1 | .. |
| Soap Manufacturing | 36 | 1 | 2.8 | 1 | .. | .. | .. | .. | .. | 1 | .. | .. | .. |
| Stamping and Sheet Metal Works | 65 | 6 | 9.2 | 3 | 2 | 1 | .. | 2 | 3 | .. | 1 | .. | .. |
| Tanneries | 66 | 5 | 7.6 | 4 | .. | 1 | .. | .. | .. | .. | 4 | .. | 1 |
| Tenant Manufacturing | 724 | 11 | 1.5 | 1 | 2 | 6 | 2 | 1 | 5 | 2 | 3 | .. | .. |
| Wall Paper Factories | 20 | 2 | 10.0 | .. | 2 | .. | .. | .. | .. | .. | 2 | .. | .. |
| Warehouses | 375 | 25 | 6.7 | 8 | 8 | 6 | 3 | 3 | 13 | .. | 6 | 3 | .. |

## Table II.

### Secondary Supplies to Sprinkler System.

| Occupancy | Total No. of Fires | Secondary Supply: When a Factor | Secondary Supply: % Total | Primary Supply: Waterworks | Primary Supply: Gravity Tank | Primary Supply: Pressure Tank | Primary Supply: Misc. Pumps | Secondary Supply: Waterworks | Secondary Supply: Gravity Tank | Secondary Supply: Pressure Tank | Secondary Supply: Steam Pump | Secondary Supply: Misc. Pumps* | Secondary Supply: Steamer Connection |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Waste and Batting Mills | 353 | 12 | 3.4 | 6 | 2 | 4 | .. | 2 | 2 | .. | 3 | 3 | 2 |
| Waste Paper and Rags | 80 | 4 | 5.0 | .. | .. | 4 | .. | 3 | 1 | .. | .. | .. | .. |
| Weaving Mills | 144 | 7 | 4.9 | .. | 7 | .. | .. | .. | .. | .. | 4 | 3 | .. |
| Woodworkers, Class A*. | 215 | 12 | 5.6 | 8 | .. | 3 | 1 | 1 | 3 | 1 | 2 | 4 | 1 |
| Woodworkers, Class B*. | 240 | 18 | 7.5 | 6 | 5 | 6 | 1 | 2 | 8 | .. | 3 | 3 | 2 |
| Woodworkers, Class C*. | 171 | 8 | 4.7 | 2 | 4 | .. | 2 | .. | 4 | .. | 2 | 2 | .. |
| Woodworkers, Class D*. | 126 | 7 | 5.5 | 5 | .. | .. | 2 | 1 | 4 | .. | 1 | 1 | .. |
| Woodworkers, Class E*. | 194 | 3 | 1.5 | 2 | .. | 1 | .. | .. | .. | .. | .. | 3 | .. |
| Woodworkers, Class F*. | 45 | 5 | 11.1 | 2 | 2 | 1 | .. | 2 | 1 | .. | 2 | .. | .. |
| Woolen Mills | 1016 | 70 | 6.9 | 24 | 38 | 3 | 5 | 1 | 10 | .. | 28 | 31 | .. |
| Worsted Mills | 82 | 2 | 2.4 | 1 | 1 | .. | .. | .. | .. | .. | 2 | .. | .. |
| Total | 21,557 | 1216 | | 339 | 603 | 221 | 53 | 116 | 204 | 14 | 575 | 271 | 36 |

*The Woodworkers are classed as follows:

Class A. Interior woodwork, builders' supplies (including veneer works).

Class B. Box Factories (including cigar boxes).

Class C. Miscellaneous Woodworkers. Steam power tenant woodworkers (also woodworkers where there is a lack of detailed information as to class).

Class D. Sash, Door and Blind Factories.

Class E. Hard Wood Turning (wheels, pipes, novelties, bobbins, spools, etc.) last and wood heel factories).

Class F. Pails and Woodenware. (Plates, wooden bowls, tubs, etc.).

*Miscellaneous pumps include water supplies reported as automatic steam pump, automatic electric pump, automatic fire pump, fire pump, rotary pump and pump with no designation of type.

longer available for the sprinklers and the value of the secondary supply, a 20,000-gallon gravity tank, was very clearly demonstrated, especially in view of the fact that the plant is mainly of frame construction. It was this second supply that kept the fire from getting a hold on the interior of the buildings and undoubtedly saved the plant from very serious if not complete loss. About 10,000 gallons were used from the gravity tank.

**29124. Cordage Works.** Fire broke out in the basement of the head house, due to friction of rope used in driving a pulley. A metal guide had become detached and allowed the rope to rub against woodwork. All eight sprinklers in the room opened. The waterworks pressure on the sprinkler mains was increased by the steam pump, used as a secondary supply, and as the fire appeared serious the plant fire department also used this pump to supply four hose streams. This effectively checked the fire and averted a large loss.

**28603. Warehouse.** Fire occurred in box cars in an adjoining freight yard and was swept by a brisk breeze up to an unsprinklered warehouse about 70 feet west of the sprinklered warehouse. The former was destroyed and flames reached across the space, burning out wood frames of windows in the west wall of the warehouse; 76 sprinkler heads opened at the window openings on all floors. Two pressure tanks of 4,500 gallons each and a gravity tank of 30,000 gallons were drained. The fire department connected to steamer connections. Two leads of hose were run up to gravity tank also, but this tank caught fire and began to leak, so that this method was abandoned. The sprinklers prevented the fire from entering the building. There was considerable water damage to contents and fire damage to building.

**19246. Furniture Factory.** Fire occurred from unknown cause in a corner of the filling room. It attacked a dip tank, making a severe blaze. The sprinklers were effective in keeping the fire confined to the corner of the room, 20 heads opening. The sprinklers were supplied from a six-inch waterworks dead end main with a 40,000-gallon gravity tank as a secondary supply. Three private hose streams were put on the fire as well as two from the city department. The main did not give adequate flow for the streams, so the gravity tank was called on to supply both the sprinklers and the hose streams. About 15,000 gallons were used from the tank.

**29259. Box Factory.** Fire started on the roof of building over the glue room and veneer-drying room. It is believed that sparks from the boiler stack were the cause of the fire. The fire spread rapidly over the composition-covered portion of the roof, creating a severe heat. About 130 heads opened in the glue room and 80 in the veneer-drying room, but they could not put water on the fire as it did not burn openings in the roof. An automatic fire pump was the primary supply with a gravity tank as secondary supply. Owing to such a large number of sprinklers opened it was difficult for the fire pump to maintain sufficient pressure. The gravity tank became the acting supply before the fire was under control and did a good part as a supply to the sprinklers. Fire on the roof was finally extinguished by private hose streams with the aid of the city fire department.